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ABSTRACT

Concerned about the effect rising energy costs would have on their local affiliates, building consultants for national social welfare agencies have been advocating the initiation of energy management and conservation programs. This manual, a three-part educational and planning tool, is a key element in a program developed to help local agencies conserve energy and save dollars. Section 1 is an introduction to energy management. It addresses concerns about the rising costs of energy and outlines a nine-step program to minimize these costs. This section also introduces sections 2 and 3 and explains how to use them. Section 2 is a resource section that contains a glossary of energy management terms; a compendium of articles and exercises relating to heating, cooling, lighting, and other building systems; and a detailed bibliography of other energy reference works. Section 3 is a workbook that consists of a step-by-step energy conservation plan that is practical and based on the principle of agency self-help. (MLF)

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ENERGY MANAGEMENT FOR HUMAN SERVICE AGENCIES

SECOND EDITION

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FOREWORD

For the past several years, building consultants for national social welfare agencies -- particularly the YWCA, YMCA, Jewish Welfare Board and Boys' Clubs of America -- concerned about the effect rising energy costs would have on their local affiliates, have been advocating the initiation of energy management and conservation programs. A number of executives and board volunteers have responded positively and, as a result, have managed to keep their organizations' expenditures for electricity, heating oil and gas within reasonable boundaries. Those who did not heed the warnings, however, are now having to face the rapidly escalating costs of lighting, heating and cooling their buildings, and many are in a bind! Some fortunate few have met the problem by raising more dollars, but they are the exception. Most organizations have been forced to make drastic cutbacks, such as dropping a staff member, closing the swimming pool, reducing hours of operation, closing the building for an extended period or cutting back on activities. Now they are asking, "What will we do as inflation continues and the situation becomes even more critical?"

The answer is still the same, because there is no magic cure for energy-related problems. Organizations must institute energy conservation and management programs. Fortunately, the job is now easier, as all national organizations affiliated with the National Assembly of National Health and Voluntary Social Welfare Organizations have joined forces with Educational Facilities Laboratories and the United Way of America to combat the problem.

Working under grants from both Exxon Corporation and Ittleson Foundation, a program has been developed to help local agencies conserve energy and save dollars. A key element in the program is this manual. Developed by the staff of Educational Facilities Laboratories, a division of the Academy for Educational Development, in conjunction with a special committee composed of national agency building consultants, this manual -- written in layman's terminology -- is the best guide available to agency leaders. Be sure to use it so that your agency may be able to reap the financial benefits of a properly administered energy management program.

William J. Lavery
Director
Building Consultation Services
Boys' Clubs of America,
Chairman
Energy Management Committee
National Assembly Task Force on Buildings

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ACKNOWLEDGMENTS

This manual, developed by the Educational Facilities Laboratories division of the Academy for Educational Development, for the National Assembly, could not have been realized without the creativity and commitment of key EFL staff.

Preparation of the resource component required a review of existing literature and selection of appropriate materials either for inclusion in the manual (rather than reinventing the proverbial wheel), or as recommended supplementary reading by manual users. This work was diligently undertaken and accomplished by Charlene Landis.

The workbook is the heart of the manual. It provides the agency energy team with a step-by-step guide through the energy management process. The development, structure and organization of the workbook was done by Joshua Burns.

The readability and accuracy of the manual is owed in large part to Amy Friedman, who reviewed and revised the various drafts of this work.

The concept and structure of the manual, its philosophic approach to energy management and how to communicate it, is owed to Sy Zachar, Project Director.

Finally, a special thanks to Pearl Jacobs, Project Coordinator for the National Assembly, who not only reviewed materials for the manual but also contributed to it.

We thank Exxon Corporation and Ittleson Foundation for their support of the manual and the energy management program of which the manual is a part. Exxon's Loren F. Kahle, Jr. was a most helpful advisor and reactor at various stages of development.

But the real test of the manual is in its effective use as a tool for energy management and conservation. That now is your task.

Alan C. Green
Senior Vice President AED
Director EFL Division

CONTENTS

SECTION I: YOUR PROGRAM TO MANAGE ENERGY

INTRODUCTION.....1-1
GETTING THE MOST OUT OF THIS MANUAL.....1-5
ESTABLISHING AN ENERGY MANAGEMENT PROGRAM (EMP).....1-7

SECTION II: ENERGY MANAGEMENT RESOURCES

INTRODUCTION.....2-1
GLOSSARY.....2-3
BIBLIOGRAPHY.....2-9
STATE ENERGY OFFICES.....2-23
WHY AND HOW AGENCIES USE ENERGY.....2-27
ADMINISTRATIVE SYSTEM.....2-31
BUILDING ENVELOPE SYSTEM.....2-39
LIGHTING SYSTEM.....2-57
VENTILATION, HEATING AND COOLING SYSTEMS.....2-63
WATER SYSTEM.....2-71
SWIMMING POOL AND NATATORIUM.....2-73
PROFESSIONAL SERVICES FOR ENERGY MANAGEMENT.....2-75
MODEL "MAXI-AUDIT" CONSULTANT CONTRACT.....2-77
LIFE-CYCLE COSTING.....2-83
BASIC DATA AND REFERENCE TABLES.....2-91

SECTION III: ENERGY MANAGEMENT WORKBOOK

INTRODUCTION.....3-1
STEP ONE: OBTAIN AGENCY COMMITMENT.....3-3
STEP TWO: FORM ENERGY MANAGEMENT TEAM.....3-9
STEP THREE: GATHER DATA.....3-13
STEP FOUR: REVIEW DATA.....3-127
STEP FIVE: ESTABLISH GOAL.....3-151
STEP SIX: DEVELOP ACTION PLAN.....3-153
STEP SEVEN: IMPLEMENT PLAN.....3-157
STEP EIGHT: MONITOR CONSUMPTION.....3-163
STEP NINE: EVALUATE PROGRAM.....3-165

SECTION I: YOUR PROGRAM TO MANAGE ENERGY

INTRODUCTION

Ours is not the first energy crisis. Although we may feel unique in history and time, we are in many ways repeating a cycle of events; one whose outcome in the past was not always negative.

Ancient Rome, whose source of energy was slaves, had a serious energy crisis. As the empire began to decline, the energy supply -- conquered people -- diminished. Prices rose, and the government's attempt to impose price controls failed.

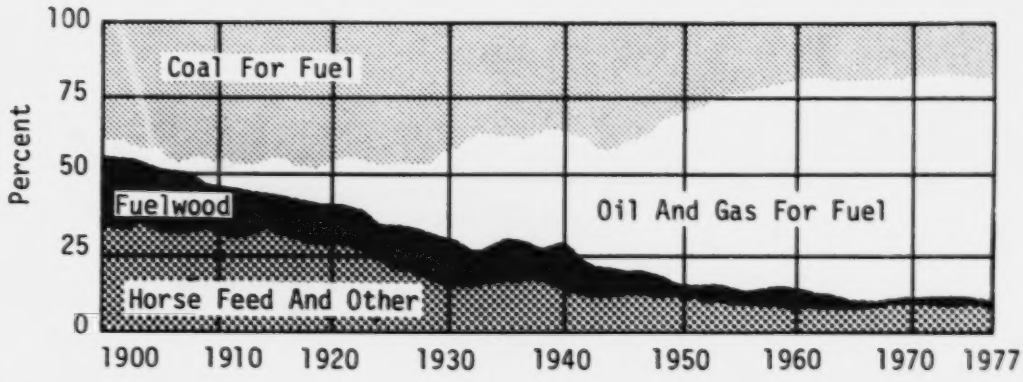
It became necessary to tap new energy sources. Water power, in the form of the water wheel, became that "new" source of power (although the technology had existed for centuries). Water "energy" powered Europe through the Middle Ages, and was essential to the success of America's early development and industrialization.

Rome also had a wood crisis. In the latter part of the fourth century, Roman ships scoured the known world, offering to buy wood at any price. Elizabethan England had a wood crisis as well. Wood was used for everything from building material to kitchen fuel. To meet demand, England not only leveled her own forests, but also decimated lands in Scotland and conquered Ireland.

An energy crisis threatened America in the years prior to the Civil War. Until that time, whale oil had satisfied nearly all indoor lighting needs. But, as whalers gradually killed off the great Atlantic whale herds, supplies became increasingly scarce, and the price of a gallon shot from 23¢ to $1.45.

Whale oil's chief competitor was kerosene made from coal, but it was so expensive to produce that it could not compete economically with whale oil. Kerosene could be made from crude oil, but the crude was available only where it seeped from the ground. Of course, this situation changed in 1859, when oil gushed from a well in Pennsylvania, for the first time. Within a decade, the whale oil market had collapsed, and the oil age was born.

Consumption of Energy Materials in the United States: 1900-1977



The oil age was slow to develop, but by the end of World War II, we were a nation fueled heavily by petroleum. Our post-World War II prosperity was aided by cheap oil from Texas and abroad -- oil so cheap, in fact, that prior to the Arab oil embargo of 1973, a good hamburger in New York City cost more than a barrel of Saudi Arabian crude. Until quite recently, a gallon of cola was more expensive than a gallon of gasoline. (While not used in the same quantities, we are still confronted by the economic value of a gallon of gasoline vs. that of a gallon of cola.)

A glance at the evening news gives the impression that high energy costs are undermining our society. They are causing inflation; they are adding to a trade imbalance; they are lowering our standard of living. Studies predict oil shortages. More studies minimize the possible contributions of alternative energy in the near future. Conservation, we have been told, must become our new way of life. A former President appeared on national television wearing a sweater. A new President favors decontrol of energy prices. High prices, we are told, are desirable: they will limit demand and increase supply.

Fear and Loathing

But despite the staggering amount of energy information generated in the last decade, we still seem to know or care little about saving it. At fault, perhaps, is the quality of this information. We are awash in a sea of energy news and data, but the "facts" often seem contradictory. A report of an imminent gasoline shortage appears alongside a story about an oil glut. In the case of nuclear power and synthetic fuels, the information is not only contradictory but frequently unintelligible to all but the most technically astute. And from a psychological point of view, energy conservation, once synonymous with kindly Smokey the Bear, now conjures in our minds images of cold, dark rooms and waiting in line for gas.

We are still adjusting to the country's changing energy situation. Our reaction so far has been a mixture of anger, uncertainty, confusion and resistance to change. We had been conditioned to expect a steadily increasing state of material well-being; it is a shock to realize that the energy abundance of the post World War II years is the exception rather than the rule in terms of world history. It is also difficult to accept that a country as large, rich and industrial as ours can't swiftly resolve its energy problems. So it is not surprising that, while we say the energy problem is real, our efforts to conserve have been slight. After making a token offering to the Idol of Energy Conservation, we have returned to our inefficient ways; some of us look to Washington, others hope for technological deliverance, but most would prefer not to think about it at all.

It is helpful to pause here and consider how our country's businesses have been coping with rising energy costs and scarcities. Since 1973, this sector of the economy, operating under the principle of rational decision making, has led the way in conserving energy. Of course, business has the financial and technical resources to invest in conservation measures (and unlike human service agencies, business can pass along many of its increased costs). But the primary reason for its success in conserving energy is that the business sector has clearly perceived the benefits. Energy represents money, and cutting energy costs can often mean the difference between profit and loss.

This same principle holds true for an agency such as your own. Rising energy costs mean you will have less money to provide services. Your agency will not go out of business, but you may have to cut staff or curtail programs (limit the hours the pool is available, eliminate winter nighttime programs, etc.). It is possible that your agency might raise additional funds, but in a troubled economy, this becomes more difficult.

The alternative is to manage energy. There is a catch, however. Your agency may institute this energy management program, and consequently, cut consumption 15 percent in the first year. But during that same year the price of energy may rise 20 percent. Despite your conservation efforts, your total energy costs will still have increased slightly. This is what is known in energy parlance as cost avoidance. There is no profit to report -- your agency hasn't gained anything -- but you may have saved a staff position or rescued an endangered program.

Less Energy, More Planning

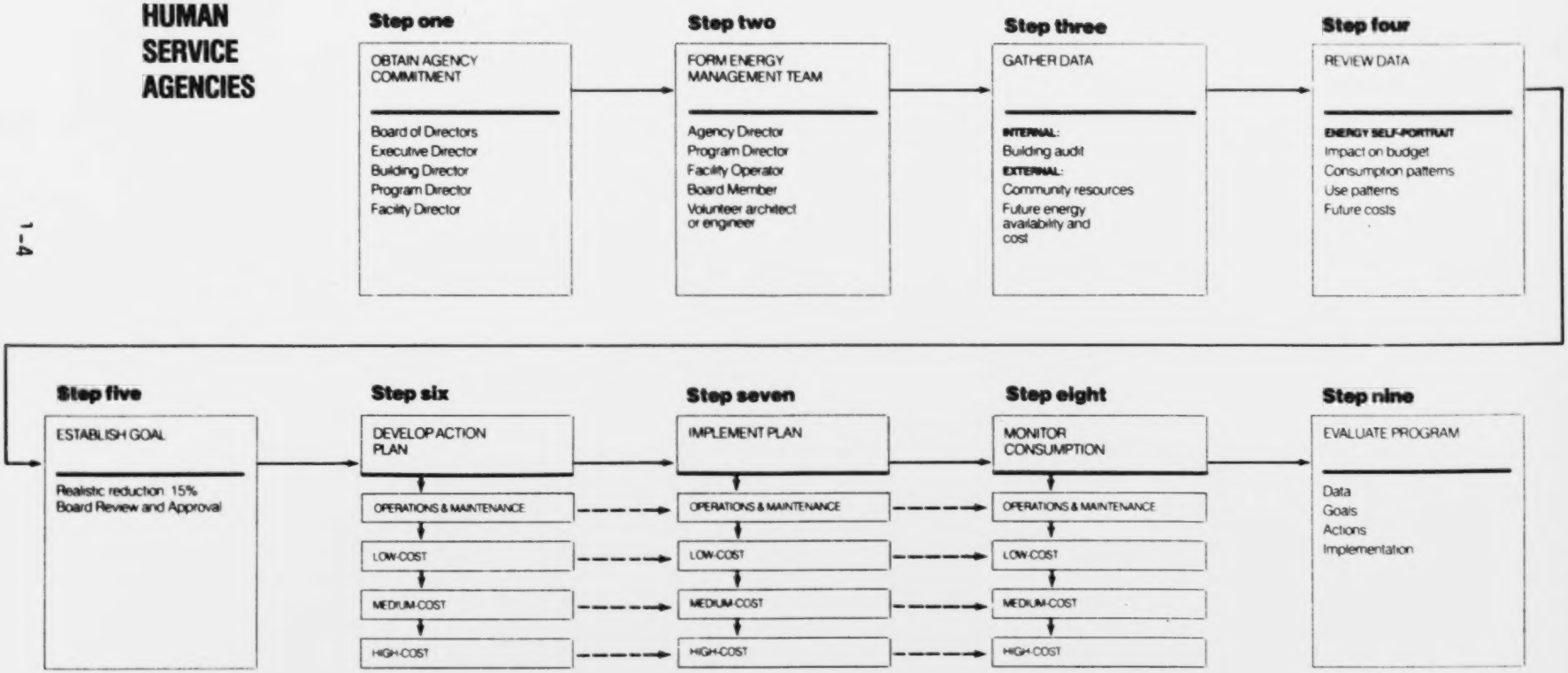
This manual will teach you how to save energy in your building. It assumes no prior knowledge of energy conservation, nor does it assume that past agency energy policies were incorrect. If your agency has been inactive in regard to energy, the program in this manual is an ideal way to begin to do something about it. If your agency has already begun conservation measures, this manual will help you refine those measures into a coherent program.

The important thing is to start thinking of energy as a problem you can do something about, not as the exclusive province of OPEC oil ministers or distant business and government officials. Setting up an energy management program is primarily a matter of intelligent planning; of thinking more rationally about how to use your environment. Taking on a new task when you can barely meet the demands on your time may seem overwhelming. Your initial reaction to this manual, for example, may be that it will be inscrutable or that it is too much work. Just keep in mind that it has been carefully prepared to minimize any confusion and at the same time provide an effective basis for your program. Think of the manual's step-by-step plan as a recipe for energy management; following it will be similar to baking a cake.

The case for implementing the program in this manual is compelling. Energy costs are expected to double in the next five years. Energy management is necessary if you are to continue to provide current services and meet new demands. Moreover, your conservation efforts will have an impact beyond the walls of your building. Agencies such as yours reach one out of two Americans, either directly or indirectly. They can, therefore, serve as community models for energy conservation. And it will reflect favorably on your agency to demonstrate to its supporters that it is actively working to hold costs in line.

If decontrolled, the price of oil and gas will rise. But subjecting energy prices to a free market also allows the consumer greater control. While the user might feel entirely at the mercy of energy-producing companies and foreign governments, his/her use also influences prices. We all compete in one marketplace for energy. The more energy we use, and therefore, the more we compete, the higher prices will rise. Only by lessening demand, individually, organizationally, and socially, can we prevent energy prices from rising higher and faster.

ENERGY MANAGEMENT FOR HUMAN SERVICE AGENCIES



GETTING THE MOST OUT OF THIS MANUAL

Energy Management for Human Service Agencies is a three-part educational and planning tool that will help your agency save energy. If the program outlined in this manual is followed with reasonable dedication, in one year your agency can expect to cut its energy consumption by 15 percent. In some cases, agencies may even save up to 25 percent.

Of course, the manual by itself will not save energy. It will educate you and your staff in basic energy management techniques. It also details a plan for saving energy in your own building that is both comprehensive and comprehensible. But the final responsibility for implementing such a plan will rest with you and the agency staff.

Section I, which should be read first, is an introduction to energy management. It addresses your concerns about the rising costs of energy and outlines a nine-step program to minimize these costs. This section also introduces Sections II and III and explains how to use them.

Section II is a resource section. It contains a glossary of energy management terms, a compendium of articles and exercises relating to heating, cooling, lighting and other building systems, and a detailed bibliography of other energy reference works.

The bibliography is not included in this manual simply as a matter of form. Because buildings which house human service agencies are so varied, no one manual can hope to cover every topic in sufficient detail. Therefore, you are expected to order those materials pertaining to your particular type of building and agency program. Two of these works, Total Energy Management (TEM), and Put Your House to Work Saving Money for You!, are provided for your convenience. TEM is considered to be the best general energy management manual available, and you are advised to read it. Put Your House to Work Saving Money for You! has been included for small house-centered agencies because its approach and information make particular sense for these types of buildings. You should order the other relevant materials now so they will be available when you are ready to use them. As you receive these materials, use Section II to house them. It will eventually comprise a small but compehensive energy management library.

Section III is a workbook. It is here that the lessons of Section II will be applied to save you energy. This section consists of a step-by-step energy conservation plan that can be adopted by your agency. This plan is practical and based on the principle of agency self-help. However, you should not attempt the more technically demanding worksheets until you have thoroughly digested Section II and the supporting materials that must be ordered.

Studying your building through this manual and developing the knowledge to implement an energy management program will be a learning experience for your agency. You will have to learn a new vocabulary and ways to consider past

practices in a new light. It may also require release time for a member of the agency staff, especially in the early stages of the program. But the money saved by energy conservation will quickly repay the investment of staff time.

This manual contains the best information currently available on energy management that is applicable to human service agencies. It's now up to you to use it.

ESTABLISHING AN ENERGY MANAGEMENT PROGRAM (EMP)

The management of energy is comparable to the management of other resources such as money and personnel. Only the language is different. Energy management requires a willingness to learn some new concepts, an understanding of how a building uses energy, and a four function (+, -, x, ÷) calculator. Given these, an agency should be able to carry out an energy management program using existing personnel and bringing in community resources when needed. The program can begin immediately, and the results should soon be reflected in lower consumption.

If an agency were faced with a sudden increase in personnel costs, it would not simply reduce its staff by X percent. It would assemble data on program requirements and personnel costs, review the information in terms of agency goals, develop recommendations for the board, develop strategies based on its recommendations, and then implement them. Finally, the agency would monitor and evaluate the effects of reduced personnel on the program.

The development and management of an energy conservation program is similar to administration of a personnel program. In fact, energy management is easier than personnel management. A Btu has never filed a grievance for being cut!

The management of energy follows a basic process which is outlined in the workbook's nine steps, as illustrated in the chart on page 1-4.

Step One - Obtain Agency Commitment

No agency effort can succeed without the support of the board of directors, executive staff, operating personnel, clients and tenants.

The Board. The support and understanding of the board are essential. The board must convey to the executive staff that their work in energy is important and vital to the agency's financial stability. The executive director must exhibit leadership and convey to the staff a commitment to

energy management if they are to take the program seriously. The board must understand that the program will require agency funds, both directly and indirectly. Staff members working on energy management will not be performing routine duties. Release time may be appropriate for one staff member. In addition, some energy conservation measures will require special allocations. The board must look at them carefully, and understand that to save money, or to achieve a cost avoidance, it may have to spend money. For those measures which have a payback (see Glossary) of less than one year, the money already exists in the utility account of the agency's budget.

Operations Personnel. The people who operate and maintain a building are an integral part of any conservation program. Old habits die hard. Operating personnel may resent an intrusion into their domain, especially if they think their work is being criticized. It is important to get these people on your side early in the game, or the program is likely to fail. Keep in mind that they know and understand how the building operates better than anyone else. Their knowledge is invaluable.

1. Make sure that they are part of the team, and they are given the opportunity to participate as full team members.

2. Explain that things must be done differently in order to save energy.

3. Stress the fact that energy conservation saves dollars, and therefore enhances job security.

An important part of energy conservation is keeping track of consumption and costs. This requires a little extra effort by one of your clerical personnel, and his/her cooperation must be enlisted.

The cooperation of clients and tenants will also be necessary for the program to succeed. The agency must communicate to building users why the agency is instituting an energy program, why their cooperation is necessary and what they can do to help.

IF YOU ARE A TENANT . . .

1. If you are a tenant, and pay your own utility bills, do all the appropriate operations and maintenance steps listed in the Action Sheets.

2. If you have a long-term lease (and pay your own utility bills), you may wish to make some modifications to the facility which have a quick enough payback to save you money.

3. Work with your landlord in instituting an energy management program. Your rent should be adjusted to reflect savings the landlord might achieve.

4. Work with other human service agencies and the United Way to bring pressure on landlords to institute conservation measures which will reduce your fuel and utility consumption.

To facilitate this first step, the workbook (Section III) includes the following sheets:

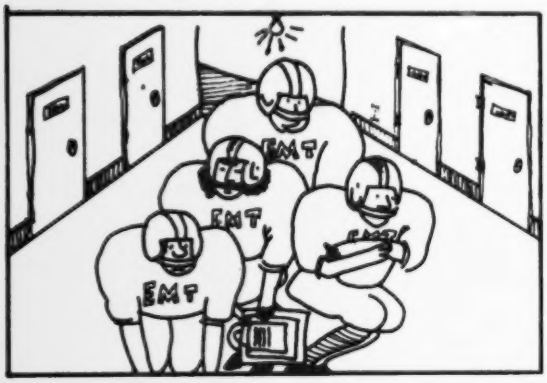
1. A checklist of activities for developing and obtaining agency commitment (Worksheet 1-0).

2. A preliminary schedule and suggested completion dates (Worksheet 1-1).

3. A sample policy statement that may be adopted by a board of directors (Worksheet 1-2).

4. A guide to help identify proposed members of the agency's Energy Management Team (EMT) who will develop and administer the program (Worksheet 1-3).

5. A calculation sheet for determining how much the staff time will cost the agency so it can determine if the payback will be more than 15 percent (Worksheet 1-4).



Step Two - Form Energy Management Team (EMT)

As suggested on Worksheet 1-3, the Energy Management Team (EMT) should include the principal staff members whose job responsibilities directly and indirectly affect energy consumption. This includes the agency director, program director, building director, business manager, facility operator, volunteer treasurer and other personnel who influence operation of the facility. As with any type of program or management effort, results are best obtained when one person is charged with responsibility for the program. The coordinator of the EMT may be any of the above central people. It depends on the agency. The chairman is not an honorary post; the person accepting the job accepts a long-term responsibility. All energy policy will center around this individual, who must be given the power needed to implement this policy. Staff support, financial resources and temporary relief from other duties may be appropriate until the program is established.

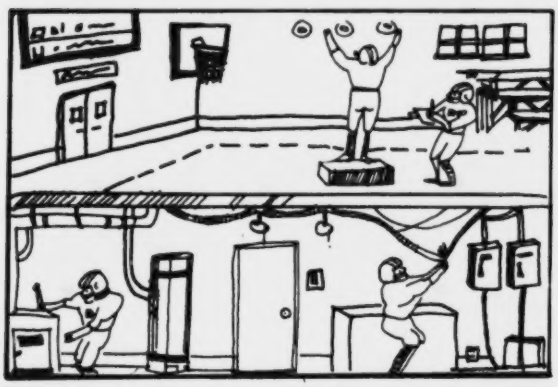
Once the team is formed, members should develop a work schedule for the energy management program at their facility. The workbook provides a detailed

listing (Worksheet 2-1) of major program activities and approximations of how long it should take to complete the individual tasks. These time estimates are based on the assumption that during its first year, the EMP will be a high priority of the agency, while also recognizing that energy management is not the only responsibility of agency staff.

In general, the schedule allots one week for each of the stages, and assumes the agency will complete the facility audit, review the information, establish goals and be ready to begin implementation in six weeks. This may seem fast -- and it is -- but so is the rate of increase in energy costs. It also indicates that the process is not as difficult as it appears.

While it may be impossible to adhere strictly to the outlined schedule, make every attempt to do so. Once your energy program begins to develop, a certain momentum will build, and you should make every effort to continue that momentum.

The team may also include a professional (perhaps a volunteer) with architectural, engineering or some other form of energy background. The team should not rely on this individual to lead, rather, he/she should be viewed as a resource. In the future you may have to hire a professional engineer to do detailed facility analysis. But this shouldn't happen until the team has done as much within the facility as possible.



Step Three - Gather Data

Neither your agency nor the team can proceed without first establishing an information base from which to formulate recommendations and actions. The agency and team must gather data from both outside and inside the agency. Outside the facility, the team should identify local resources that can provide technical help and information. This includes other social service agencies, the United Way, a local college, university or hospital, local utilities or major industry.

The team must also try to estimate future energy costs and the availability of the agency's principal fuel. For example, will natural gas or fuel oil supplies be adequate in the foreseeable future, and at what price? The time frame for availability and price estimates should be five years into the

future. While no one knows with any certainty what the future of energy supply and price will be, it is important to develop some sense of future trends. Even though the answers will only be "guesstimates," they do place a handle on future costs, and therefore provide guidance for present actions and necessary planning.

Worksheet 3-1 will help you identify local community resources, and Worksheet 3-2.2 will help you prepare estimates of future energy costs. Sources of information are your own records, your electric utility, fuel supplier and your state energy office. Another good resource is your local newspaper, as well as general observation of what is happening to energy costs in your area and nationwide. If you have difficulty obtaining estimates, you may use an annual escalation rate of 15 to 20 percent as a rough guide.

The "Walk-Through" Energy Audit. The second step in developing a data base is to do an energy audit. The term audit is somewhat misleading since it implies an exactness in accounting that is not always possible or necessary. An energy audit is simply a determination of how much, where, and how effectively a building uses energy. The first audit should be a walk through the building by the EMT. This may be the first time some team members have been in the boiler room or basement. The walk should follow the flow of heating, cooling and hot water through the building. Questions should be asked: What does this switch control? Why is this exhaust fan on? Where does this duct lead? What time does this heater go on in the morning? Is all equipment turned off at the end of the day? How many air changes do the gym, cafeteria or auditorium have per hour? Does this continue all day?

Team members should examine the building using all senses. Why are lights on in an empty room? How much heat escapes through those badly warped windows? Is the first floor drafty while the top floor is stifling (with the windows open)? How do clients use (and waste) energy? Only after team members are familiar with their building should they consider a second audit with an engineer from the local utility or an outside consultant. The more the EMT knows about its own facility, the more it can gain from outside expertise. Be your own building expert first.

The energy audit is complex and time-consuming, but the end result is information on which to base decisions. An understanding of agency energy use is essential to the success of the management program.

More Detailed Audits. The workbook contains five audit sections:

1. A Facility Audit (FA), which gathers information about the building and its systems.

2. An Energy Audit (E), which looks at recent energy use and weather conditions (remember that energy use is climate dependent).

3. A Space Use Audit (U), which examines space use and scheduling.

4. Action Self-Audits, which identify specific energy deficiencies and suggest operation and facility improvements to correct them.

5. An optional Expanded Facility Audit (FB), to calculate energy savings. This survey is designed for larger, sophisticated facilities with access to technical expertise. This does not mean that small agencies cannot use this worksheet but it will greatly benefit the larger (over 20,000 sq. ft.) agency.

All the audit sheets examine the facility from an energized, nonenergized and human systems orientation. Specific sheets cover the agency's physical structure and its energized systems, including cooling, heating and lighting, and its hours of operation.

The Space Use Audit is particularly important. It asks the team to look carefully at how the facility is used, and to examine ways it might be used more efficiently. Different parts of agency buildings are used at different times. In most large facilities, various zones are controlled by separate thermostats. Agency staff should know which thermostats control each zone. It is important to be aware of these zones when scheduling activities for different spaces. If several rooms are needed, for example, using rooms in the same zone will allow thermostats in the unscheduled portions of the building to be set back. By grouping activities, spaces and scheduling, your facility can be made more energy efficient.

Action Sheets. Based on the understanding of the facility the team gained from the energy audits, reading the materials in Section II, including Total Energy Management and the other materials ordered, you should be ready for the Action Sheets.

Each Action Sheet concentrates on a specific problem. The team or an individual member should check off whether the problem exists at your facility, or "Will find out" if unknown. If the problem does exist, the sheet suggests maintenance and operational procedures ("Do these") to rectify the problem, followed by systems modification solutions ("Consider these"). In virtually all cases, the "Do these" should be done first. The "Consider these" should usually be done with the assistance of an outside professional who can help determine the feasibility and payback of these suggestions.

For example, Action Sheet A-1 asks if space temperatures are reduced when your building is unoccupied. If not, the sheet directs you to reduce heating thermostat settings by a minimum of 10°F (at least to 55°F) at night, over weekends and during holidays. If there is no danger of freezing, the sheet also directs you to shut the heating system off completely during these periods (the same holds true for the cooling system). As a more long-term measure -- and one requiring an investment of more than just staff time -- the sheet asks the agency to consider installing time clocks and an automatic energy management control system.

The Action Sheets are the heart of the management process. They are both working documents and a permanent record of decisions and action covering three phases of the energy management process. Problems, via questions, are identified (Step Three), strategies and actions are detailed (Step Six), and responsibility for carrying out each action is assigned and its completion is indicated (Step Seven). You will, therefore, be referring to the Action Sheets throughout the energy management program. In a year they should be the most dog-eared pages in the manual.

Step Four - Review Data

The data review process pulls together all the information the agency has collected about itself. It is an energy self-portait. Components of the self-portrait should be:

1. Projections of energy cost one to five years from now.
2. Energy costs as a percentage of building and agency budget.
3. Building and program schedules and their impact on energy use.
4. Energy consumption patterns for the past three years.
5. Principal low-cost conservation measures identified by audits.
6. Preliminary energy savings from low, middle and high-cost measures.
7. Awareness of facility use patterns, impact on energy use and cost by staff and clients.

The worksheets in the manual include estimate sheets for determining energy savings and cost avoidance. While it is not necessary to prepare savings estimates to gauge the validity of certain actions, estimates will help the agency determine its priorities in developing appropriate suggestions and staff and resource allocations.

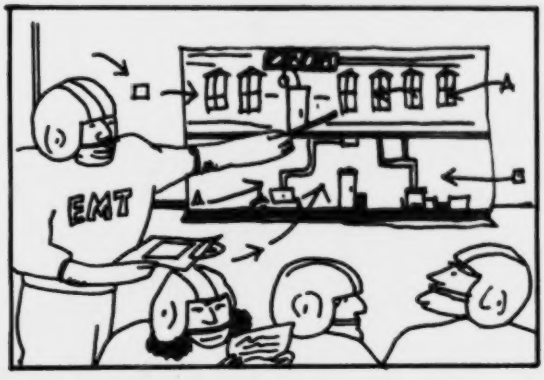
The estimate sheets may look formidable, but they are not. They can be done by a nontechnical person using a simple pocket calculator. The worksheets are not difficult, but they do take time. It is strongly recommended that you take the time to do these, to understand fully the various conservation measures and what types of savings to expect. As the program continues over the years, you will gain a good understanding of how and where your facility uses energy. These worksheets will also be extremely helpful in establishing your energy reduction goals and targets.

Step Five - Establish Goal

Once the team knows its facility, has determined the possible energy savings and cost avoidance and has reviewed the agency's resources, including personnel and their time commitments, it should establish a realistic energy reduction goal and a target date for achieving it. All team members should agree on the goal and target date and feel they are attainable. The goal should not be so simple as not to challenge the team or affect a solid energy reduction, nor so difficult that it is virtually unattainable. The first year goal should be about 15 percent. Later in the program, during the evaluation step, the team should consider whether the goal was realistic, in terms of setting subsequent goals.

The team should present the energy self-portrait and reduction goal to the board. This should be done without hesitancy. The purpose of this entire program is to prepare for the future, not review the past.

The workbook provides an energy goal statement (Worksheet 5-1). Once the goal is approved by the board, the team should publicize the goal to all agency users and clients, soliciting their support and cooperation.



Step Six - Develop Action Plan

Based on review of all the action sheets and the development of energy savings and cost avoidance data, the team must now determine the order in which tasks should be accomplished. The workbook provides a basic outline (Worksheet 6-1) for organizing the action plan.

The action plan can be divided into four categories, based on ease of implementation, level of reduced consumption and payback. These categories are operations and maintenance, and low, medium and high-cost actions. Operations and maintenance (O&M) is a critical component of energy conservation. This is actually a no cost item. Generally, O&M and low-cost strategies can reduce energy use between 20 percent and 25 percent; medium and high-cost strategies can result in an additional 20 percent reduction.

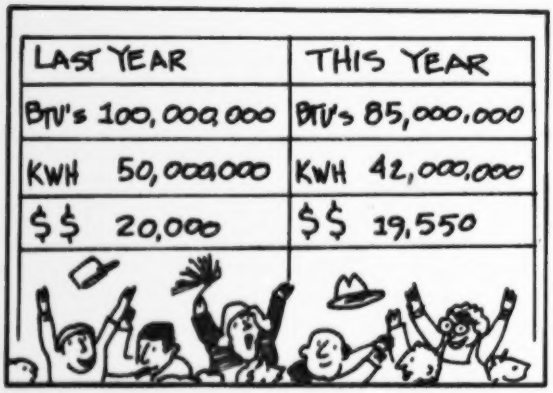
Responsibility for developing strategies can be divided among members of the EMT based on job responsibilities. If the O&M and low-cost items reduce energy consumption 10 percent to 20 percent, the agency will easily meet its first year goal. At the same time, the team will become familiar with energy conservation and management. The agency should probably do only O&M and low-cost measures during the first year. During the second year, after all low-cost measures have been realized, team members should examine medium-cost measures. At this point, familiarity with payback and cost benefit will pay off. Also, the experience of working with consumption and degree-days, conversions to fuels and energy use to Btu's and the general concepts of conservation will make the second and third year efforts more fruitful.

Many of the medium and high-cost measures should only be done with the assistance of an architect or engineer. For information on hiring an outside consultant, see the article in Section II.

Step Seven - Implement Plan

Implementation is the administration of the program. It is simply who does what, when, where and with what resources. Sequence tasks so that those with the greatest energy saving or quickest payback are done first. Establish schedules and target dates for completion of tasks.

Implementation is the ongoing "nitty gritty" of making changes in the facility and its operation to achieve the targeted savings. It includes training personnel, schedule modifications, changes in building use patterns, performing maintenance, educating staff and clients; energized systems: delamping areas, introducing task lighting, upgrading boiler efficiency, balancing building temperatures; and nonenergized systems: installing weatherstripping, closing curtains and limiting the number of doors that are used. Implement your plan and indicate completion on Action Sheets A, B, L, S, VX, V, H, C, W and P. To assist your O&M action plan, Worksheet 7-1 provides a boiler log maintenance sheet.



Step Eight - Monitor Consumption

The only way to measure the impact of your energy management program is to monitor it. As you implement each measure, energy consumption should drop. If you carefully monitor and evaluate consumption, you will see the success or effect of individual tasks and the overall program. Chart your savings or cost avoidance. The money that would have been spent on energy is instead going into programs.

Components of this step are:

1. Each month (or more frequently) record fuel and electricity used. Keep a permanent record, and post figures on program achievement wall charts.

2. Institute an EMT weekly, bi-weekly, and/or monthly review of program progress, and make corrections when necessary.

Step Nine - Evaluate Program

Evaluation is the final step (see Worksheet 9-0). Just as you evaluate service programs to make sure that they meet their goals and objectives, you must evaluate the energy management program. Evaluation will determine whether the program is meeting its goals and also what impact it has had on clients and agency programs. Evaluation should also determine if the data gathered provided the right information, if more is necessary, whether the goal was realistic, too high, or too low and whether the strategies and their implementation schedule work. For example, which of the energized, nonenergized, and human systems provided the best savings and payback? Where should future emphasis be placed? What should the next goal be, and what strategies should be pursued next?

Components of this step are:

1. A quarterly review of program activities, achievements, shortfalls and motivation.

2. At the end of each year, enter annual results on Objective Statement and evaluate results.

* * * * *

You have now completed Section I of the manual. You may be tempted to turn directly to Section III and begin the workbook, but resist this temptation. Take the time to become familiar with the contents of Section II. This material will be helpful to you in filling out the workbook. Also take time now to order the additional reference works listed in the bibliography of Section II.

SECTION II: ENERGY MANAGEMENT RESOURCES

INTRODUCTION

Before proceeding any further with your energy management program you should become familiar with the vocabulary that will be used throughout the workbook. We provide a glossary for this purpose. The glossary is the key to understanding the terminology of energy conservation and management. Look it over now, and refer back to it when necessary.

Total Energy Management (TEM), one of the better manuals available, contains a brief description of each system in a building, which will enable you to understand the suggested procedures in the Action Self-Audit. Like the glossary, you should read TEM now, and refer back to it when you use the Action Sheets for each particular system. You should also read at least one other manual listed in the bibliography.

Although Put Your House to Work Saving Money for You! is included primarily as an aid to facilities located in buildings best described as "like a house," everyone should spend a few minutes skimming this simple but practical guide. It's a painless way to get started, and you'll find it of great help in your own home.

Systems

The following chapters provide basic facility management information, coupled with cross references to additional materials. The sections parallel the Action Sheets. If you have difficulty as you fill out the Audit and Action Sheets, these materials will fill in gaps and help answer your questions.

If you are not familiar with this type of material, trying to review it all in one sitting may prove frustrating. A better approach is to review the information both in this manual and the works cited as thoroughly as possible. Take your time. As you work through the Audit and Action Sheets, go back, and go back again if necessary. The material isn't that hard -- it's just new. And don't forget to use Total Energy Management.

GLOSSARY

air changes: Replacement of air in a room over a period of time. Measured in cubic feet per minute (cfm).

ampere: A unit of measure of an electric current.

ballast: A device used in starting fluorescent and high intensity discharge lamps.

benefit/cost ratio: The relationship between the annual benefit (savings) of a piece of equipment and the cost of achieving that benefit, or annual savings/annual costs. This is used in life-cycle costing.

boiler capacity: The rate of heat output in Btu/hr. at the boiler outlet under rated conditions.

British thermal unit (Btu): The standard unit for measurement of the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit. Generally speaking, one Btu is about equal to the amount of heat given off by a wooden match.

building envelope: All exterior surfaces of a building that are subject to climatic impact; walls, windows, roof.

cash flow: The inflow and outflow of dollars in a given period.

caulking: A flexible material used to seal cracks or spaces.

ccf: A hundred cubic feet. Used as a measure for billing natural gas.

cfm: Cubic feet per minute. A rate of flow, usually used to measure air changes in a room.

comfort zone: The temperature and humidity range in which most people feel comfortable.

compressor: A machine that reduces the volume of a refrigerant vapor.

condenser: Part of a refrigeration machine which extracts heat from hot refrigerant gas for rejection from the machine.

conduction: The transfer of heat through a solid.

convection: Heat transfer by the motion of a fluid or gas, usually air.

cost avoidance: The dollar difference between energy cost for a facility with and without conservation measures.

cost/benefit ratio: See benefit/cost ratio.

damper: A valve or movable plate in a duct or flue for regulating the flow of air or other gases.

degree-day: A unit that represents a one degree Fahrenheit deviation of the mean daily outdoor temperature from a fixed reference temperature of 65°.

discounting to present value (discounted cash flow or present value analysis): Direct application of the present value concept that one dollar today is worth more than one dollar received in the future, used in life-cycle costing.

degree-day, heating (hdd): A unit used to estimate the heating requirement of a building. For any one day, when the daily mean temperature is less than 65° F, there exist as many degree-days as the Fahrenheit degree difference in temperature between the daily mean temperature for the day and 65° F. The sum of the daily degree-days constitutes the annual degree-day heating requirement.

degree-day, cooling (cdd): A unit used to estimate the cooling requirement of a building. For any one day, when the daily mean temperature is greater than 65° F, there exist as many degree-days as the Fahrenheit degree difference in temperature between the daily mean temperature for the day and 65° Fahrenheit. The sum of the daily degree-days constitutes the annual degree-day cooling requirement for small buildings and residences. Humidity and other factors should also be taken into consideration when calculating cooling requirements.

demand load: The requirement of electric energy measured in 15-minute cycles for commercial operation. The price of electric usage is directly related to the level of this demand. The higher the demand, the higher the cost per electric unit.

demand charge: The charge for the highest (or peak) kilowatt use for the month, which is billed in addition to the billing for total energy consumed in kilowatt-hours.

double-glazed: A window with two panes of glass or other transparent material.

dry-bulb temperature: The temperature indicated by an ordinary thermometer.

ductwork: The conduit or piping system through which warm or cool air is conveyed from the supply source to the premises or outlet. Ducts are usually made of galvanized metal or fiberglass; they may be lined or covered with insulating materials.

efficiency of fixtures: The ratio of usable light to energy input for a lighting fixture or system (lumens/watt).

energy audit: Any process that examines energy consumption in a facility and enables one to identify measures for energy and cost reduction.

fan coil: A heating device that blows air through a hot radiator coil.

first costs: The initial cost of a capital investment.

flue: A boiler exhaust outlet that connects boiler to stack.

foot-candle: Units for measuring the amount of light. It is the intensity of light at a distance of one foot from a standard candle. Light meters measure in foot-candles.

glazing: Glass in windows.

heat gain: The amount of heat gained by a space from all sources, including people, lights, machines, sunshine, etc. "Total heat gain" represents the amount of heat that must be removed from a space to maintain desired indoor temperatures during the cooling season.

heat loss: The heat lost from a building when the outdoor temperature is lower than the desired indoor temperature. It represents the amount of heat that must be provided to maintain desired indoor temperatures.

heating load: The total rate of heat loss from a building under given conditions, measured in Btu/hr.

heat pump: A refrigeration machine that extracts heat from air and is capable of reversing the flow so that its output can be either heating or cooling. A refrigerator uses a heat pump to transfer heat from one medium (called the heat source) to another (called the heat sink), thereby cooling the first and warming the second.

horsepower: A unit of power; 1 hp = 746 watts or 42.408 Btu's per minute.

HVAC: Heating, ventilating, and airconditioning.

infiltration: The process by which outdoor air leaks into a building through cracks around doors, windows, floors, etc.

insulation: A material with high resistance (or R value) that is used to minimize heat losses from a space.

internal rate of return: The interest rate that makes the present value of the cash proceeds from an investment equal to the present value of the cost of the project. This is used in life-cycle costing.

kw (kilowatt): 1,000 watts.

kwh (kilowatt-hour): A unit of energy equal to the energy expended by 1,000 watts in one hour (3,413 Btus).

latent heat: Heat in the air resulting from the moisture content of the air. The higher the relative humidity, the higher the latent heat.

life-cycle costing: A method for estimating the cost of equipment over its entire life, including operating and maintenance costs. It enables the cost of proposed alternative systems to be compared.

load leveling: Deferring certain electric loads to limit power demand to a predetermined level.

load profile: The time distribution of building heating, cooling, and electric load.

lumen: A measure of the amount of light produced by an electric lamp. Two lamps with the same wattage may differ substantially in the amount of lumens they produce; for example, a 40-watt incandescent bulb and a 40-watt fluorescent bulb.

luminaire: A complete lighting unit including lamp, shade, reflector, fixture, and other accessories.

maxi-audit: An extensive study of HVAC systems, building shell, and facility utilization patterns, usually conducted to determine viability of large-scale retrofits.

payback: The time required for the cost of energy saved to equal the total cost of modifications, i.e., the time for an investment to pay for itself.

peak load: The maximum predicted demand for any system. The term is used in a general sense to describe the amount of load above the base load for electrical billing.

power: The rate at which work is done.

radiation: The transfer of heat from one body to another by heat waves without heating the air between the bodies.

relative humidity: The percentage of moisture in the air. Higher humidity allows lower temperatures and still provides an acceptable comfort level.

R value (resistance): The term used to measure insulation materials resistant to the flow of heat or cold. It is expressed in units of square feet per hour per degree Fahrenheit per Btu. The higher the R value, the better the insulation.

retrofit: The improvement of existing buildings to make them more energy efficient.

sensible heat: Heat that results in a change in temperature so that it can be "sensed" or felt.

simple payback: The amount of time necessary for the money saved by using a piece of equipment to equal the cost of the equipment.

solar load: The quantity of heat gained by a building, which increases indoor temperatures as a direct result of sun shining on the surface and entering through windows, etc.

therm: A unit of measure of heat energy, equal to 100,000 Btu's. Five therms equal 500,000 Btu's.

thermostat: A device that establishes and maintains a desired temperature in a heating or cooling system.

ton of refrigeration: A term for expressing cooling capacity. One ton equals 12,000 Btu/hr.

U value (coefficient of heat transfer): The rate of heat loss through a building surface. The lower the U value, the less heat transferred, and thus the more energy-conserving the insulation.

vent: Any penetration designed for the flow of air through the building envelope.

ventilation: The introduction of air into a space by a controlled mechanical system or unit.

ventilation air: Supply air that comes from outside the building plus recirculated air that has been treated to maintain the desired quality of air within a space.

vapor barrier: A layer of material to prevent moisture migration, usually added to insulation.

watt (w): A measure of electric power consumed by a lamp, appliance, motor, etc.

weatherstripping: Metal, plastic, or felt strips which prevent air infiltration around windows and door frames.

wet-bulb temperature: The temperature indicated by a wet-bulb thermometer (one with a moistened bulb). High wet-bulb temperature indicates high water vapor content in the air; low wet-bulb temperature indicates low water vapor content.

zone: A space or group of spaces within a building with heating and/or cooling requirements controlled by a single thermostat.

BIBLIOGRAPHY

In addition to Total Energy Management and Put Your House to Work Saving Money for You! each facility should order at least one of the reference materials listed below. These have been specially selected from the bibliography because they are the most helpful in planning an energy management program for a particular type of facility.

ORDER THESE MANUALS NOW. Most take between two and three weeks to arrive. You want to have them on hand to refer to as you perform the Facility Audit. Complete ordering instructions are included in the bibliography.

Energy Conservation Standards is a book all small and medium-sized facilities should order. This book and TEM will be your most used references. It's worth the investment.

Large facilities with sophisticated maintenance staffs may want to order How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings. This is a technical book, not appropriate for small or even medium-sized buildings in the early stages of an energy management program.

Facilities best described as "a small office building" should order Reducing Energy Costs in Religious Buildings. Don't be misled by the title. The information pertains to many types of buildings.

Large office buildings should order Multi-Family Housing Energy Conservation Workbook, which will be most informative to the nonmaintenance staff.

Kitchen information is best gained from Energy Conservation Manual, Wisconsin Restaurants.

If your facility has a residence, we recommend that you order the Energy Conservation Manual developed for use in hotels and motels.

If your program contains light industrial operations you may find Energy Management for Industrial Operations useful.

GENERAL WORKS

Title: Architecture and Energy
Author: Richard Stein
Publisher: Anchor Press, Doubleday, New York
Publication Date: 1977
Price: $12.95; paper, $6.95

This book is easy to read and understand. It does not provide energy conservation information per se. Rather, it explains the principles of energy consumption in buildings and their use in heating, lighting and operating. Technical terminology is explained and the reader can quickly and easily comprehend the basic principles of environmental control. The book, written for the nontechnical person, is well documented and indexed.

In a chapter titled "A History of Comfort with Low Technology," the author reminds us that we once lived well without massive energy consumption. Other sections are devoted to energy problems of the glass-faced, sealed building; contemporary material design and use; the over-lighting of buildings; and the energy waste caused by "environmental control."

Primarily, the book provides important background information on the principles of building design and energy consumption.

Title: Building Operating Management
Publisher: Building Operating Management
2100 West Florist Avenue
P.O. Box 694
Milwaukee, Wisconsin 53209
Subscription: monthly magazine, $15.00 a year, $1.50 per copy

Building Operating Management is a good, basic magazine devoted to building operations and maintenance. Good facility and equipment maintenance are central to energy management. Each issue includes at least one energy conservation article. Advertisers often offer valuable information free of charge. These ads also provide continuing information on the rapidly changing energy product market.

As with Energy User News (see below), each issue will probably contain at least one idea or piece of information that you can use. This periodical should reach everyone who has facility responsibility, and back issues should be kept for reference.

Title: The Economy of Energy Conservation in Educational Facilities
Publisher: Educational Facilities Laboratories/AED
680 Fifth Avenue
New York, New York 10019
Price: $4.00

First published in 1973, and revised in 1978, this work is considered a "classic" in the school energy field. It is included here because many agencies resemble school buildings in design and construction; both contain instructional, recreational and dining facilities.

The work covers planning for energy management, operating and maintenance changes, modernizing buildings for energy conservation, and planning new construction with energy efficiency in mind. The book is well written, easy to understand, and rich in ideas.

Title: Energy Conservation Manual
Publisher: The Hospitality, Lodging and Travel Research Foundation, Inc.
888 Seventh Avenue
New York, New York 10019
Publication date: 1977
Price: $45.00

Buildings with residential components, such as Y's, will find this loose-leaf book helpful. It provides information enabling you to decrease energy consumption without making guests uncomfortable.

The emphasis is on operations and maintenance, for instance, no-cost ways in which employees can alter their cleaning routine to reduce energy needs. Employee motivation is considered. Areas covered include: housekeeping, front office, food and beverage preparation, meeting and convention facilities, laundry and security. Employee checklists are suggested for each area. Swimming pools are mentioned briefly.

The variety of energy conservation opportunities in the area of sleeping rooms and guest corridors is amazing. Although many of them taken individually will appear insignificant, the cumulative effect will be quickly apparent.

Title: Energy Conservation Manual, Wisconsin Restaurants
Publisher: Wisconsin State Energy Office
101 South Webster
Madison, Wisconsin 53702
Price: free

This manual was designed to help owners and managers of restaurants reduce energy consumption without curtailing services. Therefore, it can be used

by any facility whose kitchen is a major component. The emphasis is on proper maintenance of equipment, replacement of old equipment with more energy efficient models and improved scheduling of tasks.

It contains a chart of energy usage for various pieces of kitchen equipment, and another comparing energy usage in table service vs. fast food operations.

This is the best information available on energy conservation in kitchens.

Title: Energy Conservation with Comfort
Publisher: Honeywell
to order, contact your regional Honeywell office
Publication Date: 1979
Price: free

Both simple and complex solutions to the dilemma of managing conservation with comfort are offered in this excellent handbook designed for managers of nonresidential buildings. It gives basic ideas for controlling energy use, plus some ideas on how to use solar energy, thermal storage, power factor correction and computerized energy management techniques. However, the emphasis is on starting conservation with efficient, well-maintained operating controls before moving into more sophisticated techniques.

Energy Conservation with Comfort is highly recommended as an addition to any facility library.

Title: Energy Conservation Standards for Building Design, Construction, and Operation
Authors: Fred S. Dubin and Chalmers G. Long, Jr.
Publisher: McGraw-Hill, Inc., New York
Publication Date: 1978
Price: $22.50

As the title indicates, this book deals with standards, so it is a good companion to the Action Sheets. For instance, when more information is needed to evaluate the performance of a heating or cooling system, or to determine the operating efficiency of a lighting system as it affects energy conservation, this is the book to consult. The text and the numerous charts, graphs, nomographs and other aids enable you to trace and measure the energy flow in a building as a first step in choosing a conservation option.

Energy Conservation Standards is a much condensed and simplified version of How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings, another book Mr. Dubin contributed to, which is also cited in this bibliography. Unlike the earlier work, this book is not intimidating and will be an invaluable reference to energy management teams in facilities of all sizes.

Title: The Energy Efficient Church
Publisher: The Pilgrim Press
287 Park Avenue South
New York, New York 10010
Publication date: 1979
Price: $4.95

This book encourages readers not to waste energy heating and cooling unused portions of their buildings. The largest rooms in a church, for example, are probably used infrequently, and yet these rooms are often heated constantly. This book is recommended for buildings with intermittent use, where some rooms are used daily, and others less frequently.

The book gives first emphasis to reducing inefficiency, second to reducing demand and third to reducing building load. The book has a very good section on the relationship of programming to energy consumption. Thermostatic zones and efficient scheduling are discussed. Also, there are suggestions for ways that volunteers can help, a good "how to" section on caulking and weatherstripping and a clear and concise discussion of life-cycle costing.

Title: Energy Future
Report of the Energy Project at the Harvard Business School
Author: Robert Stobauch and Daniel Yergin, Editors
Publisher: Random House, New York
Publication date: 1979
Price: $12.95 hardback; $2.95 paperback (Ballantine Books)

This is a comprehensive overview of the energy issues facing our nation. It gives the reader a vast amount of information that is highly readable--even enjoyable.

You may not wish to read the entire book, but focus on sections which are of particular interest and concern -- mainly the chapters on the primary heating or cooling fuel your agency uses. The three chapters titled "The End of Easy Oil," "After the Peak: The Threat of Imported Oil," and "Conservation: The Key Energy Source," provide a clear understanding of how we arrived at where we are today and what we must do for the future, and show how easily conservation can become a key energy source.

This book connects the agency's concerns with those of the nation and the world. It gives the reader an understanding of why energy management is so important -- indeed, imperative.

Title: Energy Management for Colleges and Universities
Publisher: National Association of College and University Business Officers
One Dupont Circle, N.W.
Washington, D.C. 20036
Publication date: 1977
Price: $20.00

This sophisticated manual is designed for large facilities with building managers and staff. Of particular value are the sections titled "Energy: Its Conversion, Use and Waste" (which explains how energy is used in different types of heating and cooling systems); how to establish an "Energy Data Base"; and a phased or "Evolutionary Approach to Energy Conservation" (which takes the reader from no and low-cost energy conservation measures to system conversions).

The manual also provides information on purchased utilities (electricity, gas and steam), the financing of conservation measures, determining the rate of return on investments, as well as the organizational incentives necessary to mount a successful program.

Title: Energy Management for Industrial Operations
Publisher: Minnesota Energy Agency
980 American Center Building
150 East Kellogg Building
St. Paul, Minnesota 55101
Publication date: 1976
Price: free

This workbook covers all building systems, but with special emphasis on energy conservation in an industrial plant. An agency with light industrial components in its programs may get some tips from the sections on Material Handling Operations, Paint Line Operations, Process and Manufacturing and Welding.

Title: Energy Management Process
Publisher: JC Penney Company
Public Affairs Department
1301 Avenue of the Americas
New York, New York 10019
Publication date: 1978
Price: free

This is a well-organized, easy-to-use manual that would be a good addition to an energy management library. The section on lighting illustrates the variety of lamps and fixtures. Another section on materials and equipment will be useful to administrators considering installation of automatic timers, load control devices, etc.

Title: An Energy Management Program for Multi-Story Office Buildings
Publisher: New York State Energy Office
Agency Building No. 2
Rockefeller Plaza
Albany, New York 12223
Price: free

This workbook contains 20 worksheets to calculate payback periods and estimate savings for each of 20 retrofit options, such as insulating heating pipes, replacing boiler controls, installing steam traps and thermostats, removing lights or changing from incandescent to fluorescent lamps. The worksheets detail the data required for calculations, explain how to do calculations and give sample problems.

Its best use is by building operators who want additional help with savings estimates where retrofit is being seriously considered.

Title: Energy User News
Publisher: Energy User News
7 East 12th Street
New York, New York 10003
Subscription: weekly newspaper, $36.00 annual subcription

Energy User News, while aimed at managers of large commercial and institutional facilities, can be used beneficially by all readers regardless of building size. Each week it provides the latest information on energy costs, conservation, technology, selected events in Washington and product information. Each issue contains several major articles on conservation and management. While no single issue will tell you how to meet all of your energy needs, the cumulative effect of reading this weekly will be beneficial, especially if the issues are circulated to your staff. If you get one good idea and use it, the subscription will have paid for itself.

Title: Facility Maintenance Systems
Author: John J. Murray, ASLA
Publisher: Girl Scouts of the U.S.A.
830 Third Avenue
New York, New York 10022
Publication Date: 1980
Price: $7.00

A good maintenance program is the foundation of an energy management program. This manual provides an outline for a property management system, and model record keeping systems. Those wishing to delve deeper will find the extensive reference and bibliography sections helpful.

Title: Fundamentals of Boiler Efficiency
Publisher: Exxon Company, U.S.A.
P.O. Box 2180
Houston, Texas 77001
Publication date: 1976
Price: free

The title of this excellent 19-page booklet is self-explanatory. How boilers work and ways to make them operate efficiently are explained in simple terms. It covers the basic principles of combustion and boilers, boiler design, fuels and boiler efficiency. This booklet should be in every energy conservation library.

Title: Guidelines for Federations on Energy Conservation
Publisher: Council of Jewish Federations
575 Lexington Avenue
New York, New York 10022
Publication date: 1977
Price: free

A concise work (26 pages) written specifically for agency facility personnel, it contains basic energy conservation information. Specific sections discuss conservation through reducing infiltration, controlling ventilation, increasing the efficiency of the heating and cooling system and reducing lighting and electric demand.

Title: Housekeeping Handbook for Institutions, Business and Industry
Author: Edwin B. Fedlaman, P.E.
Publisher: Frederick Fell Publishers, Inc.
386 Park Avenue South
New York, New York 10016
Publication date: 1978
Price: $19.95

If you do not have a good maintenance program, you will not have a good energy management program. That is the reason for listing this work, which covers the management of maintenance. Beginning with a history of sanitation as practiced by the ancient Egyptians, it moves quickly into the development of proper maintenance and housekeeping in contemporary organizations. This is a "how to," step-by-step work. Some areas covered are housekeeping and maintenance program development and installation, standards, contract cleaning, consultants, energy conservation and housekeeping, training, surface care and graffiti control.

Title: How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings
Authors: Fred S. Dubin, Harold L. Mindell and Selwyn Bloome
Publisher: Noyes Data Corporation
Park Ridge, New Jersey 07656
Publication date: 1976
Price: $24.00

Considered by many to be the work in the field, it is the book upon which many subsequent books and manuals have been based. The book, according to the authors, was prepared "specifically for conservation of energy in existing office buildings, retail stores, and buildings which are generally occupied only a few hours a week such as religious buildings." A two volume set, Volume I helps the user conserve energy without significant investment of capital; Volume II is an engineers, architects and operators manual. This book can be used effectively by an agency executive with some technical knowledge, as well as the building engineer. This is a very thick and intimidating work, but it is easy to use. If a member(s) of the energy team is willing to spend the time to work through this book it will help your agency go beyond the conservation measures cited in this manual. This book is an excellent reference, and will save you far more than its cost.

Title: Insulation Manual, Homes, Apartments
Publisher: National Association of Home Builders Research Foundation, Inc.
627 Southlawn Lane
P.O. Box 1627
Rockville, Maryland 20850
Publication date: 1979
Price: $10.00

This is a complete book on insulation. It is well organized, informative and comprehensible. The energy and economic repercussions of installing insulation are covered. There are many "do-it-yourself" techniques described for installing insulation in walls, ceilings, floors, ducts and attics.

There are diagrams, charts and tables, a weather data chart that covers the entire country and U value and R value tables for a variety of conditions.

An agency considering insulating its building, or contemplating new construction, will find this manual most helpful.

Title: Life-Cycle Costing
A Guide for Selecting Energy Conservation Projects for Public Buildings
Publisher: Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
Publication date: 1978
Price: $2.75, stock #003-003-01980-1

This report, sponsored by D.O.E., is appropriate to large and sophisticated agencies. It provides a step-by-step guide for conducting life-cycle cost

evaluations of energy conservation projects for public buildings. It also explains the use of life-cycle costing to evaluate and rank the cost effectiveness of alternative energy conservation projects for existing and projected public buildings. Worksheets, illustrated with a realistic example and a computer program, are provided.

Title: Lighting Power Standard, A Guide to Saving Lighting Energy Dollars
Publisher: New York State Energy Office
Agency Building No. 2
Rockefeller Plaza
Albany, New York 12223
Price: free

Because it is highly technical, with difficult calculations, this book is not recommended for all agencies. However, a large agency with a fairly sophisticated maintenance staff will find a lot of useful information in the following areas: fixture delamping and relamping, modification and replacement, illumination system controls and maintenance procedures for maximum efficiency.

Title: Multi-Family Housing, Energy Conservation Workbook
Publisher: New York State Energy Office
Agency Building No. 2
Rockefeller Plaza
Albany, New York 12223
Price: free

This manual provides good compilation of basic information which will be helpful in the management of any large building. The emphasis is on operating and maintenance procedures, especially equipment maintenance. There are many diagrams, photographs and descriptions of test procedures.

The strength of this manual is that it can be used by program staff as an energy conservation primer to help them to understand a building's systems.

There is a chart of estimated payback periods for 75 retrofit options, and 23 worksheets to determine savings by making operational changes.

Title: Put Your House to Work Saving Money for You!
Publisher: Exxon Company, U.S.A.
P.O. Box 2180
Houston, Texas 77001
Publication date: 1979
Price: free

The discussions and explanations in this 64-page book are pragmatic and easy to read. Because the approach is "do it yourself," the book presents all

information needed to understand and carry out the procedures, and it explains why each task should be done. It is good reference material for a small facility.

There are suggestions for energy conservation measures that may even be usable in buildings a little larger than houses.

Title: Reducing Energy Costs in Religious Buildings
Publisher: The Center for Information Sharing
77 North Washington Street
Boston, Massachusetts 02114
Publication date: 1978
Price: free to Massachusetts residents. Outside the state; 1-2 copies $2.25 each, 3-5 $1.80 each, 6-50 $1.60 each, 51-99 $1.25 each, 100 $.96 each.

This book offers a common sense approach to energy conservation for agencies housed in small office buildings. It is recommended especially to the program staff as a reference along with TEM. The explanations of building systems are simple and clear.

The section on lighting illustrates the different types of bulbs and fixtures, and makes cost comparisons.

Title: Rodale's New Shelter
Publisher: Rodale Press
33 East Minor Street
Emmaus, New Jersey 18049
Subscription: $9.00 a year for 9 issues

Small facilities will gain many new ideas from this magazine each month. The emphasis is on conservation of energy and materials, and alternatives to what we usually think of as "necessary" expenses. It covers everything from wood-burning stoves to lawn care to build-it-yourself playground equipment. For example, a recent issue had an article on correct installation of insulation and another on how to design and build a solar air collector into the wall of a house.

Title: Total Energy Management
A Practical Handbook on Energy Conservation and Management
Publisher: National Electrical Contractors Association
7315 Wisconsin Avenue
Washington, D.C. 20014
Publication date: 1979
Price: 1-3 copies free; 4-500 copies $1.00 each

One of the better manuals yet developed, Total Energy Management (TEM) explains how energy is consumed in buildings, and includes information on the energy implications of infiltration, ventilation, lighting, solar gain and the impact of occupants. One section discusses a building's major systems and explains in detail their energy conservation opportunities.

This is an invaluable manual for agencies of all sizes and at different levels of a conservation program. TEM should be in the library of any facility interested in cutting energy consumption, and should be referred to frequently.

Title: Windows for Energy Efficient Buildings
Publisher: Lawrence Berkley Laboratory
Program 90-3111
1 Cyclotron Road
Berkley, California 94720
Publication date: 1979
Price: free

Buildings lose a great deal of heat through windows. This publication is a research and development report describing types of glass, other relevant products and shades and blinds. The introduction states that the intent is to issue the publication periodically as additional information is reviewed and compiled. An agency that is considering replacement of window glass, drapes or shades with more energy-efficient models should obtain this booklet and get on the mailing list.

NONFOSSIL BASED ENERGY

Title: How to Save Energy and Cut Costs in Existing Buildings
Section 22: "Alternative Energy Sources," p. 595.

Title: Solar Energy for Health Care Institutions
Publisher: U.S. Department of Health, Education, and Welfare
Health Resources Administration
3700 East-West Highway, Room 522
Hyattsville, Maryland 20782
Publication date: 1976
Price: free, may be ordered from your state energy office

This small booklet is designed to help nonresidential buildings begin the transition from energy derived from fossil fuels to energy derived from the sun. It provides a simple explanation of how solar collectors function and how the energy can be used. Cost-effectiveness is discussed, and there is some consumer information, including a bibliography.

Title: The Solar Home Book
Author: Bruce Anderson with Michael Riordan
Publisher: Brick House Publishing Co., Inc.
Harrisville, New Hampshire 03450
Publication Date: 1976
Price: $9.50

If you are interested in learning about solar energy, this book is clear, readable and informative. The work covers both active and passive solar energy. Beginning with fundamentals, it provides detailed information on numerous systems and explains practical applications, many of which can be used by agency facilities, especially smaller ones that occupy a former house or mansion. The book concludes with a "do it yourself" chapter.

At the end of each chapter, the authors provide an extensive list of additional readings. Agencies interested in exploring the solar option will find this book a good starting point and solid reference.

Title: Solar Energy Information Locator
Publisher: Solar Energy Research Institute
1536 Cole Boulevard
Golden, Colorado 80401
Price: free

This valuable pamphlet is divided into four sections: Where to start, Where to go to read more information, Where to buy more information and the Index. The addresses and phone numbers are listed for all included

organizations, as well as their area of interest, and the cost of some publications and services. One criterion for selecting organizations included in the pamphlet is that they must provide at least some free service.

Title: A Sun-Powered Hot Dog Cooker
Publisher: New York State Energy Office
Agency Building No. 2
Rockefeller Plaza
Albany, New York 12223
Price: free

This "publication" is a single sheet that lists materials needed and gives complete instructions for making a solar cooker. This would be an excellent project for a youth group; it's fun and demonstrates the principles of solar collectors. Also, you get to eat the hot dogs!

TRANSPORTATION

Title: Put Your House to Work Saving Money for You! has a section on fuel economy for private cars.

The following pamphlets are all free. They should be consulted by all agencies that have, or are considering purchasing, automobiles, that reimburse mileage expenses to employees or that are interested in encouraging efficient use of gasoline.

Title: Community Ridesharing: A Leadership Role
Publisher: U.S. Department of Transportation
Office of Public Affairs, I-38
400 Seventh Street, S.W.
Washington, D.C. 20590

Title: How to Save Gasoline and Money

Title: 1980 Gas Mileage Guide

Title: Tips for the Motorist
Publisher: U.S. Environmental Protection Agency
Fuel Economy Distribution
Technical Information Center
P.O. Box 62
Oak Ridge, Tenn. 37830

STATE ENERGY OFFICES

Alabama Energy Management Board
3734 Atlanta Highway
Montgomery, Alabama 36130
(205) 832-5010

Alaska Div. of Energy & Power Devt.
Mackay Building, 7th Floor
338 Denali Street
Anchorage, Alaska 99501
(907) 276-0508

Amer. Samoa Off. of the Governor
Pago Pago
American Samoa 96799
(Overseas Oper.) 633-1306

Arizona Off. of Planning & Econ. Devt.
Executive Tower, Room 505
Phoenix, Arizona 85007
(602) 271-4940

Arkansas Dept. of Energy
3000 Kavanaugh Street
Little Rock, Arkansas 72205
(501) 371-1370

California Energy Commission
Conservation Division
1111 Howe Avenue, M.S. 60
Sacramento, California 95825
(916) 920-6091

Colorado Office of Energy Conservation
1600 Downing Street
Denver, Colorado 80218
(303) 839-2507

Connecticut Off. of Policy & Mgmt.
80 Washington Street
Hartford, Connecticut 06115
(203) 566-5294

D.C. Off. of Planning & Devt.
1350 E Street, N.W.
District Building, Room 409
Washington, D.C. 20004
(202) 727-6365

Delaware Energy Office
114 W. Water Street
Dover, Delaware 19901
(302) 678-5644

Florida State Energy Office
301 Bryant Building
Tallahassee, Florida 32304
(904) 488-6764

Georgia State Off. of Energy Resources
270 Washington St., S.W., Suite 615
Atlanta, Georgia 30334
(404) 656-3894

Guam Energy Office
P.O. Box 2950
Agana, Guam 96910
0-1-671-472-8711

Hawaii Dept. of Planning & Econ. Devt.
P.O. Box 2359
Honolulu, Hawaii 96804
(808) 548-4080

Idaho Office of Energy
State House
Boise, Idaho 83720
(208) 384-3800

Illinois Institute of Nat. Resources
325 W. Adams, Room 300
Springfield, Illinois 62706
(217) 785-2800

Indiana Dept. of Commerce Energy Grp.
400 N. Meridian Street
Indianapolis, Indiana 46204
(317) 232-8940

Iowa Energy Policy Council
Capitol Complex
Des Moines, Iowa 50319
(515) 281-4420

Kansas Energy Office
214 W. 6th
Topeka, Kansas 66603
(913) 296-2496

Kentucky Department of Energy
Capitol Plaza Tower, 12th Floor
Frankfort, Kentucky 40621
(502) 564-7416

Louisiana Research & Devt. Div.
Dept. of Natural Resources
P.O. Box 44156
Baton Rouge, Louisiana 70804
(504) 342-4594

Maine Office of Energy Resources
55 Capitol Street
Augusta, Maine 04330
(207) 289-3811

Maryland Energy Office
301 West Preston Street, Suite 1302
Baltimore, Maryland 21201
(301) 383-6810

Massachusetts Off. of Energy Resources
73 Tremont Street, Room 700
Boston, Massachusetts 02108
(617) 727-4732

Michigan Energy Administration
P.O. Box 30228
Lansing, Michigan 48910
(517) 374-9090

Minnesota Energy Agency
908 American Center
150 East Kellogg Boulevard
St. Paul, Minnesota 55101
(612) 296-6424

Mississippi Fuel & Energy Mgmt. Div.
455 N. Lamar Street, Suite 228
Jackson, Mississippi 39202
(601) 354-7406

Missouri Division of Energy
P.O. Box 176
Jefferson City, Missouri 65102
(314) 751-4000

Montana Dept. of Nat. Resources & Consvn.
Energy Division
32 S. Ewing
Helena, Montana 59601
(406) 449-3940

Nebraska Energy Office
301 Centennial Mall South, 4th Floor
Lincoln, Nebraska 68509
(402) 471-2867

Nevada Dept. of Energy
400 W. King St.
Carson City, Nevada 89701
(702) 885-5157

New Hampshire Council on Energy
2-1/2 Beacon Street
Concord, New Hampshire 03301
(603) 271-2711

New Jersey Dept. of Energy
101 Commerce Street
Newark, New Jersey 07102
(201) 648-3290

New Mexico Dept. of Energy & Minerals
P.O. Box 2770
Santa Fe, New Mexico 97501
(505) 827-2472

New York State Energy Office
Agency Building #2, 10th Floor
Empire State Plaza
Albany, New York 12223
(518) 474-7183

North Carolina Energy Div.
Department of Commerce
P.O. Box 25249
Raleigh, North Carolina 27611
(919) 733-2230

North Dakota Off. of Energy Mgmt. & Consvn.
1533 North 12th Street
Bismarck, North Dakota 58501
(701) 224-2250

Ohio Department of Energy
30 East Broad Street, 34th Floor
Columbus, Ohio 43215
(614) 466-3465

Oklahoma Department of Energy
4400 N. Lincoln Boulevard, Suite 251
Oklahoma City, Oklahoma 73105
(405) 521-3941

Oregon Department of Energy
102 Labor & Industries Building
Salem, Oregon 97310
(503) 378-4128

Pennsylvania Governor's Energy Council
1625 N. Front Street
Harrisburg, Pennsylvania 17102
(717) 783-8610

Puerto Rico Office of Energy
Apartado 41089
Minillas Station
Santurce, Puerto Rico 00940
(809) 726-5281

Rhode Island State Energy Office
80 Dean Street
Providence, Rhode Island 02903
(401) 277-3370

South Carolina Off. of Energy Resources
SCM Center, Suite 1130
1122 Lady Street
Columbia, South Carolina 29201
(803) 758-7502

South Dakota Office of Energy Policy
Capitol Lake Plaza
Pierre, South Dakota 57501
(605) 773-3603

Tennessee Energy Authority
226 Capitol Boulevard Building, Suite 707
Nashville, Tennessee 37219
(615) 741-2994

Texas Energy & Natural Resources . Council
Advisory Council
411 West 13th Street
Austin, Texas 78701
(512) 475-5491

Utah Energy Office
231 East 400 South, Suite 101
Salt Lake City, Utah 94111
(801) 533-5424

Vermont Energy Office
Pavillion Building, 5th Floor
4 E. State Street
Montpelier, Vermont 05602
(802) 828-2393

Virgin Islands Energy Office
P.O. Box 2996
St. Thomas, U.S. Virgin Islands 00801
(809) 774-6726

Virginia Off. of Emerg. & Energy Svcs.
310 Turner Road
Richmond, Virginia 23225
(804) 745-3305

Washington State Energy Office
400 East Union, 1st Floor
Olympia, Washington 98504
(206) 754-1350

West Virginia Fuel & Energy Office
1262-1/2 Greenbrier
Charleston, West Virginia 25311
(304) 348-8860

Wisconsin Energy Off., Dept. of Admin.
P.O. Box 511
Madison, Wisconsin 53701
(608) 266-8234

Wyoming Energy Conservation Office
320 West 25th Street
Cheyenne, Wyoming 82002
(307) 777-7131

WHY AND HOW AGENCIES USE ENERGY

In order to reduce energy consumption, we must understand why and how agency facilities use energy. The "why" of energy use in facilities is simple. It is dependent on a) local climatic conditions and the need to provide a warm or cool environment for programs; and b) the amount of energy needed for the delivery of services, from lights necessary for all internal activities, to heating water for pools, showers and kitchens. Energy is used to run equipment both in the office and the shop.

The "why" of energy use cannot be altered, short of closing the agency doors. But the "how" of energy use can be changed.

THE SYSTEMS APPROACH TO ENERGY USE

Energy used in agencies can be viewed in terms of three systems: human, energized and nonenergized.

Human systems refer to the clients and staff of the agency. People require energy. A facility is energized to provide thermal comfort, light and to operate equipment. Any examination of energy use must begin with this premise. The agency must therefore focus not only on the heating system but on how people use the heating system in the facility.

The energized system is the heating, cooling, lights and equipment that directly consume energy in providing the thermal comfort, lighting and equipment necessary for delivery of services.

Nonenergized systems include the walls, floors, ceilings, windows, door and roof. They do not directly use energy, but they affect the amount of energy that is consumed. If a building's windows allow a great deal of cold air to leak inside, then more heat must be added to the environment to keep the occupants warm.

Your agency can save a lot of energy by modifying these three systems. You can improve the efficiency of the heating (energized) system, or add insulation (nonenergized system). People (the human system) can save a significant amount of energy if they turn off lights, close windows, adjust thermostat settings, maintain building equipment and structure, and coordinate program schedules to reduce the hours of building operation.

But before specific systems, and how they apply to your agency, are discussed, the factors which affect heating and cooling should be examined. Heating and cooling probably affect the three systems and your monthly energy bill more than anything else.

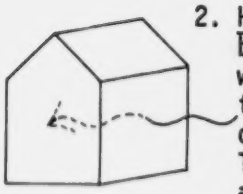
The Seven Factors which Affect Heating and Cooling

Why is a building heated or cooled? Obviously, to maintain a fixed, comfortable temperature in the building space. But what heating or cooling really do is compensate for heat loss or gain. Some of the loss or gain can be reduced by increasing the efficiency of the heating and cooling systems, or by modifying those factors which affect heat loss and gain in the building (e.g., lighting and insulation). While heat is generally lost in the winter and gained in the summer, all building systems affect this flow of heat. The seven factors that contribute to the flow are:

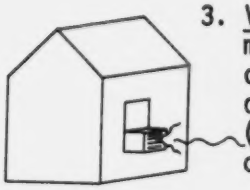
1. Infiltration: the flow of outside air into the building through existing openings (e.g., gaps between doors or windows and their frames, open doors and windows). Three factors affect infiltration:
   a. the size and number of building cracks and openings
   b. the speed and direction of the wind
   c. negative pressure systems -- when more air is exhausted than is brought in by the ventilating system, infiltration increases.

   Areas most likely to suffer from infiltration problems in small commercial buildings are loading docks and delivery entrances. These doors are often left open, and usually don't seal well when closed. Client entrances contribute to infiltration in lobby areas, especially when there is no vestibule or automatic door closer.

   Infiltration cools the building space in winter and heats it in summer, resulting in increased seasonal heating and cooling requirements.

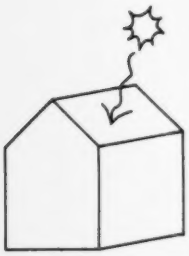


2. Heat transmission: the heat that flows into or out of the building through its exterior surfaces, such as outer doors, walls, windows, floor and roof. Heat always flows from areas of high temperature to areas of low temperature. Therefore, heat flows out of the building in winter and into the building in summer. The rate at which heat enters or leaves the building increases as the temperature difference between inside and outside air increases. The composition and insulating value of the exterior surfaces also affect the amount of heat flow.



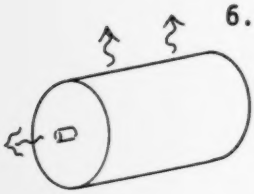
3. Ventilation: in order to reduce odors and smoke, as well as to maintain comfort inside the building, a portion of the air is continually exhausted and replaced by outside air. The amount of ventilation is normally measured in cubic feet per minute (cfm). Unlike the infiltration air, ventilation air is normally conditioned before it is introduced into the building space.

4. Lighting: in addition to providing light, lamps also emit heat. The amount of heat can be determined from wattage ratings on lamps. Heat from lighting is generally beneficial in winter because it decreases the load on the heating system. However, it increases the load on the cooling system in summer.

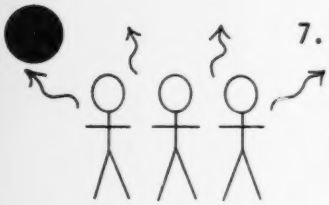


Solar gain : solar energy adds heat to the building all year round. The amount of heat received depends on:

a. the position of the sun -- this varies with geographical location, season and time of day
b. the building envelope -- this includes building orientation, shading and the type, texture and color of the building's exterior surfaces.



6. Equipment: all types of power equipment, for example, typewriters, contribute to heat gain inside a building. Many pieces of equipment are rated in watts, and the heat given off is proportional to the wattage values. Motors are sized by horsepower. One horsepower is equivalent to 746 watts.



7. Occupants: since a desirable room temperature is less than body temperature (98.6° F), occupants of a room contribute to the heating of a space. This can be significant when large numbers of people are present. Our bodies also emit moisture through perspiration and exhalation.

The combination of these seven factors creates the heating or cooling load which must be met to maintain building conditions.

ADMINISTRATIVE SYSTEM

Perhaps the most important system of all, administration includes the human element -- the people who have an impact on how much energy is consumed and when it is consumed. A facility's energy systems are designed to maintain a comfortable working environment for building occupants. These systems can be modified to become more energy efficient by establishing energy management procedures. Effective communication and cooperative effort among all people concerned is vital.

For more information see:

The Energy Efficient Church (page 26) for the best discussion of the relationship of programming to energy consumption. There are suggestions for analyzing, and possibly reorganizing, your programs so the building is most efficiently used in terms of scheduling and space allocation.

Energy Management Process has an excellent section ("Materials and Equipment") describing automatic devices, such as thermostats and lighting timers. An agency considering installation can use this information to compare different features before purchase.

Housekeeping Handbook for Institutions, Businesses and Industry is very people-oriented and has a section (Chapter 14, page 140) on energy conserving techniques.

Total Energy Management (TEM), and, if ordered, the Energy Conservation Manual for hotels or the Multi-Family Housing Energy Conservation Workbook, should be consulted. While none of these has a section specifically on the administrative system, good information is scattered all through each book. Also, TEM includes a short section on "Interior Space Utilization" (page 42).

READING UTILITY COMPANY METERS

The following information is provided to help you determine the quantity of electricity, gas or water used during any time period. This will enable the operator to check on meter readings by the utility companies, and to determine usage for time periods other than the normal utility company billing periods.

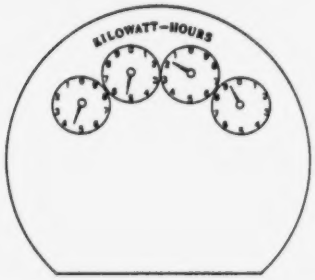
The meter dials illustrated are the most common types. It is possible that the type or style of your meters may be different, but the method of reading the dials will be the same. In general, quantities consumed are determined by subtracting initial meter readings from end-of-period readings.

Electric Meter

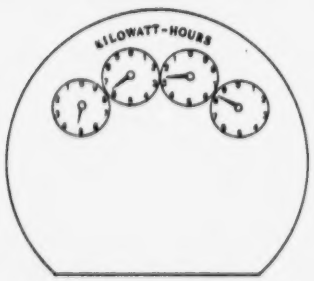
The utility companies use two major types of electric meters:

1. A kilowatt-hour meter, for customers whose rate schedule is based only on kilowatt-hours used.
2. A kilowatt-hour meter with a demand meter, for commercial customers whose rate schedule is based not only on kilowatt-hours used, but also on the maximum kilowatt demand or requirement in any 15 or 30-minute interval.

Kilowatt-hour Meter



Meter dials are read in sequence from left to right, with the number recorded being the lower of the two numbers between which the hand points in each dial. On Figure 1, the first dial is read as 4; the second dial is read as 5; the third dial is read as 1, not 2, because the fourth dial has not reached 0, but is between 9 and 0. Thus the meter reading is 4519.



On Figure 2, the same meter reads 4628.

Subtracting the first reading from the second reading will give the kilowatt-hours used. In this case, 109 kwh were used between readings.

> Multiplier: The meter face may have the words "multiply all readings by _____." If this occurs, the 109 difference in readings in the example above would have to be multiplied by the number shown to obtain the kwh used.

It may help you to understand how a meter works if you recognize that the hand on the dial at the extreme right completes one full circle, revolving from zero back to zero, while the hand on the dial next to it on the left moves only between two numbers, such as between 1 and 2. The same relationship exists between other adjacent dials.

Kilowatt-hour Meter with Kilowatt Demand Meter

Where the electric rate schedules are based on kilowatt-hours used and the maximum kilowatt demand or requirement in a 15 or 30-minute interval in the billing period, the utility company installs a meter which records demand as well as the kilowatt-hours used.

The demand meter may be a separate unit, or may be part of the kilowatt-hour meter. In a combination meter, the upper row of dials, marked "kilowatt-hours" in the upper portion of the meter face, are read in the same way as a kilowatt-hour meter.

Since there are many different types of demand meters used, each of which may be read in a different way, you should ask your utility company for instructions on how to read the demand meter that is installed at your property. However, to give you a feel for reading your meter, below are illustrations of three types of combined kilowatt-hour demand meters in common use, along with an explanation of the demand indicated.

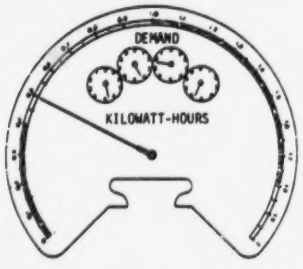


Figure 3 shows a pointer which indicates the maximum demand on the outer circular scale. The scale may be read directly, or a multiplier may be required. The demand indicated is 0.5 kilowatts. The pointer is reset to zero by the meter reader. Therefore, it indicates the maximum demand since the previous reading and billing period.

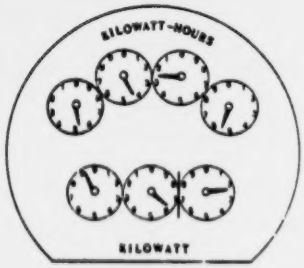


Figure 4 shows a meter with demand dials. These dials are read from left to right in the same way described for kilowatt-hour meters. The vertical line between dials indicates where the decimal point should be placed in the numbers read. If there is a multiplier shown on the dial face, the reading must be multiplied by that number. In Figure 4, the demand indicated is 96.2 kilowatts. Demand dials of this type are reset to zero by the meter reader after each reading is taken.

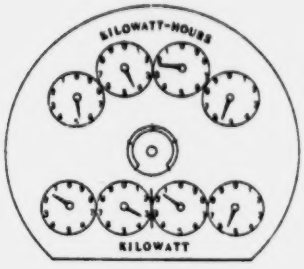
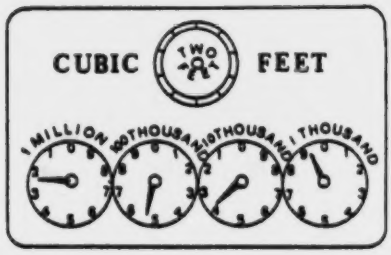


Figure 5 shows a meter with a cumulative demand register. The dials are read from right to left in the same way described for kilowatt-hour meters. The vertical line between dials indicates the placement of the decimal point for numbers read. The meter indicates 13.15 demand.

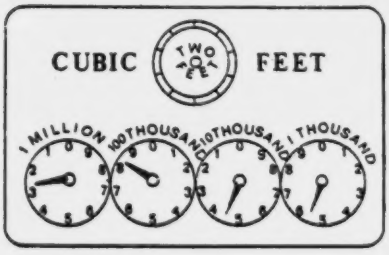
The dials on a cumulative demand register show the sum of the maximum demands from the time the meter was last read. The meter reader determines the maximum demand for the current period by taking the dial reading, then inserting a key in the meter which advances the dials to the new meter indication and taking the new reading. The maximum demand for the period is the difference between the two readings. The new dial setting remains fixed until the next meter reading.

From the above, it is obvious that the meter reader must use his key to advance the meter before you will be able to know the demand for any billing period. However, by recording the meter reading just before the meter reader arrives, and by reading the meter after he departs, you can check the demand which is used by the utility company for each billing period.

Gas Meters



In Figure 6, the single upper dial is used only to test the meter and is not read. The lower row of dials are read in sequence from left to right. In Figure 6, the first dial is read as 2, and the second dial is read as 5. The third dial is read as 3, not 4, because the fourth dial has not reached 0, but is between 9 and 0. Thus the meter reading is 2539.



In Figure 7, the same meter reads 2845.

Subtracting the first reading from the second reading will give the quantity of gas used in thousands of cubic feet. In this case, 306,000 cubic feet have been used between readings.

While most agencies will have gas meters with dials similar to these, some large properties may have a more sophisticated meter with two registers, similar to those shown on the water meter, Figure 8. This meter is called a compensating meter. It adjusts or compensates for gas temperature and/or pressure conditions at the location which are different from "standard" conditions. One register will be marked "uncorrected" or "uncompensated," and the other register will be marked "corrected" or "compensated." The "corrected" or "compensated" register should be read to determine gas usage. The "uncorrected" or "uncompensated" register is used by utility companies only for calibrating and checking the meter.

In Figure 8, the numbers which appear at the center of the meter in a row are read to determine the quantity of water used. In the illustration, the quantity read would be 2700, and would be in cubic feet, as marked on the meter. (Other meters may record gallons used, but if so, the meter would indicate this.) The pointer which moves around the outside circular dial is used only to indicate when water is flowing through the meter. The pointer and circular dial are not read to measure the quantity of water used.

REDUCING COST BY REDUCING DEMAND

Demand control offers a unique opportunity for reducing electric costs without necessarily making building environment sacrifices. Most conservation measures involve a planned reduction in energy use, such as lower lighting levels and changes in thermostat settings. Not so with demand control -- which entails regulating only the period when the load is used without limiting its performance. An added benefit of demand control is that the savings are long term and will not give rise to increased utility rates -- indeed, they operate against them.

Building Demand

The building's electric demand is the average load in kilowatts that the electric utility must provide to the building during any fixed interval, typically one of 15 or 30 minutes. It will vary from a minimum during the night to a maximum during the day. The highest recorded demand during a month is used for billing purposes. Two seasonal peak demands generally occur, particularly in electrically heated buildings: one on the hottest summer day when full airconditioning is required, and one on the coldest winter day when maximum heating is required. Design load and latitude determine which is higher; however, it is generally the summer.

Demand Charges

The electric utility's demand charge is designed to reimburse the utility for capital investment in electric plant capacity -- such as turbine generators, transformers and transmission and distribution lines. Because the utilities must have adequate capacity for the seasonal peak which will occur only a few days of the year and may be as much as 25 percent or more above "off month" requirements, many utilities have incorporated a "ratchet" or carry forward clause in the demand rate. In this case, the highest monthly demand establishes the

basis for billing during the following 11 months. Frequently, only a percentage of the highest monthly demand is carried forward, but in most cases it will be larger than your actual demand. The "ratchet" can be insidious to the extent that the demand load created in one demand period, even if created by accident, will set a cost base for the entire year. Modifications to the "ratchet" demand clause exist in the form of "time of day" and "seasonal" demand rates. Both of these rates charge more for load during the utility's peak loading period, but greatly reduce charges for off-peak periods, such as nighttime.

Demand Components

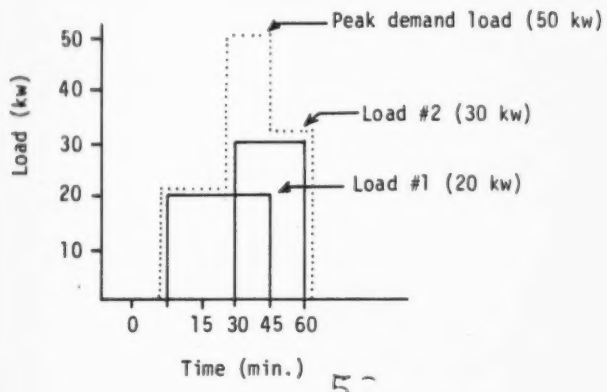
The demand load consists of constant loads, which generally don't change during business hours, and variable loads. Lighting, heating, and cooling -- all of which must operate to provide a comfortable environment -- are constant loads. Little or no opportunity for direct demand control of constant loads exists. However, certain constant loads, such as lighting, can be reduced to affect demand. Reduced lighting will lower over-all demand load, and, since lighting produces heat, reduced lighting in summer will place less call on the airconditioning system -- which will affect the demand load as well.

Variable loads exist in two states: controllable and uncontrollable. Uncontrollable loads include at least one passenger elevator, the freight elevator, kitchen appliances, pumps, and similar loads whose operating time is inflexible, and that must be available when required. Controllable loads include hot water heaters, air handlers, heating equipment, the second passenger elevator, and perhaps part of the stockroom and utility lighting, whose operation can be advanced or delayed by as long as 10 or 15 minutes without hardship or harm. For example, if a thermostat calls for heat in a hot water heater, and the operation is delayed five minutes, the temperature may drop a few degrees, but with no serious consequences. Controllable loads offer the best opportunity for demand control.

The demand load is the sum of constant, uncontrollable and controllable loads on line. When most loads are on line concurrently, which is a statistical probability, the maximum demand is established.

Demand Control

The essence of demand control is scheduling the operational time of controllable loads, allowing each its appropriate amount of time, but <u>not</u> concurrently. The following graph illustrates this concept for two devices.



The simultaneous operation of Load #1 (20 kw) and Load #2 (30 kw) resulted in a peak demand load of 50 kw. The peak demand load would have been only 30 kw if Load #2 had been delayed 15 minutes -- if it had started at 45 minutes on the graph instead of at 30 minutes, and avoided an overlap with Load #1.

Some trial and error experimentation with the theoretical maximum demand load may be required to prevent the controller from influencing the environment. If the theoretical demand load is set too low, none of the controllable load requirements will be satisfied.

The process of demand control is as follows:

1. Determine last year's maximum monthly billing demand from the Energy Audit or from your electric utility.

2. From the Energy Audit identify all controllable loads and list these loads with their size.

3. Subtract the kw total of all controllable loads from the maximum monthly billing demand to obtain a base load which will consist of the constant and uncontrollable loads.

4. Determine the approximate hours of operation of each of the controllable loads and calculate the kwh's of energy required to support their operation. Total all kwh's.

5. Divide the total kwh's of operation of all controllable loads by the daily hours open for business. You have now calculated the total effective controllable load -- as if its use were totally noncurrent and spread out over the entire business day.

6. Add the effective controllable load from Step 5 to the base load computed in Step 3 to obtain the theoretical maximum demand load for your building. This is the demand load at which the demand controller will be set.

The theoretical maximum demand load should be calculated for each month and a new demand load setting made on the demand controller. The reason is that the base load, which includes the heating or cooling requirements, will change seasonally. The exception is if a "ratchet" demand rate exists, and you are charged at the highest demand rate in any given year.

BUILDING ENVELOPE SYSTEM

The building envelope, or shell, does not consume energy directly, but it affects the amount of energy which must be supplied to the building to maintain comfort.

Two major factors affect heat gain in the summer and heat loss in the winter: infiltration and transmission.

For more information see:

TEM separate sections on infiltration (page 17) and transmission (page 31).

The Energy Efficient Church, if you want to learn how and where to caulk and apply weatherstripping yourself (page 41).

Insulation for Homes, for an explanation of everything a facility manager needs to know about insulation.

Windows for Energy Efficient Buildings, which is an important reference for a building manager who is considering buying shades, drapes, or replacing windows.

Infiltration

Infiltration is the passage of outside air into a building through openings such as cracks around windows and door jambs, doors and windows left open and outside air dampers that do not close tightly. In winter, infiltration causes heat loss. The cool outside air that enters the building must be heated to maintain desired indoor conditions. During summer, infiltration causes heat gain. The warm outside air that enters the building must be cooled. Often, additional energy must be used to treat outside air by humidification, dehumidification or filtering.

Although nonenergized elements (windows, doors) greatly affect the amount of infiltrated air, the human element is also important. Doors or windows needlessly left open by facility users have a dramatic impact on infiltration. When doors or windows are left open to offset interior temperatures that are too hot or too cold, the waste is magnified even more.

Transmission

Transmission is the amount of heat transmitted into or from a building through the various components of the building envelope, primarily exterior walls, windows, doors, skylights, roof and floors. Heat is always conducted from an area of higher temperature to an area of lower temperature. Thus during winter, heat flows from the interior through the building envelope to the exterior, causing heat loss. During summer, the process reverses: heat is transmitted from outside to inside, causing heat gain.

The rate of transmission depends on the composition and thickness of the materials used in construction of the building envelope, the difference between indoor and outdoor temperature, and the surface and area. This rate can be slowed by, among other things, adding insulation or storm windows, especially on the most affected portions of the building, and by modifying the indoor temperature.

Understanding U value and R value

Heat always flows from a warmer area to a colder area. Unless it is stopped, heat from the warm inside of a house will pass through the walls or roof to the colder outside. In the summer, the heat from outside will pass through the walls and roof into the house. Insulation creates a barrier that resists this heat flow.

In energy conservation we are concerned with the rate of conductive heat flow through various types of buildings. This is the U value of each complete structure, inside to outside. By contrast, we are also concerned with the thermal resistance of materials such as insulation, masonry, wood, plaster, etc. to heat flow through them. The thermal resistance of a material is its R value. The R value of all the materials in a wall can be totaled and the resulting total R value is the reciprocal of the U value of the structure.

This relationship of the total U value to the total R value, and to the R values of the parts of a building is useful in discussing the improvements that might be achieved by the addition of certain insulation materials.

It is best simply to remember:

1. the higher the R value, the better the insulation
2. the lower the U value, the better the insulation

U value and R value Simplified: The Coffee Cup Analogy

An easy way to visualize this relationship is to think of two cups of hot, black coffee. One cup is made of fine china, and one of styrofoam. The china cup is difficult to hold, except by the handle, whereas of course, the styrofoam cup is easy to hold, even without a handle. Styrofoam has a high R value. Heat does not move easily through it. Styrofoam resists heat movement. Because heat does not move easily through it, styrofoam has a low U value. The china cup, on the other hand, does not resist heat well, and has a low R value. Because heat does travel through it so readily, it has a high U value.

Heat Loss and Gain through Windows

On a national scale it is estimated that 20 percent of our energy goes to space conditioning in buildings. Of this, 25 percent results from heat losses and gains due to the relatively high thermal conductivity of windows -- an energy use equivalent to an average of 1.7 million barrels of oil per day.

The rate of conductive heat flow through various parts of the building envelope (glass, walls, roof, floors, etc.) is expressed as a U value. This rating is in units of Btu/hour/square foot of surface/degree Fahrenheit temperature difference inside to outside. The lower the U value, the higher the insulating value of the building. Typical wall and roof construction may vary from a U value of .4 down to .04, depending on the basic structural materials and the type and thickness of the insulation used. Single panes of glass in still air (less than 15 mph) have a U value of 1.13. Double glazing reduces the U value to about .55.

These values show there should be greater concern for heat flow through glass than through the "solid" parts of the building envelope; the exterior walls, roof and floors over unheated space. It is helpful to put this difference into some sort of perspective, by comparing the U values of areas that have the same transmission of Btu's per hour.

Assume the following reasonable U values for three windows and a wall:

Window with single glass: U value = 1.13
Window with double glass: U value = .55
Storm window and air space: U value = .56
Wall: U value = .055

We can see that the rate of heat flow through the solid wall is one-tenth of the double glazed window, which in turn is one-half that of the single glass. Since this transmission rating is based on square feet, we can also see that the same amount of heat would be transmitted through:

10 square feet of single glass window = 2.5' X 4'
20 square feet of double glazed window = 5.4' X 4'
200 square feet of solid wall = 10' X 20'

Although double glazing will reduce the amount of heat normally lost through a single glazed window by half, the degree of solar gain and wind, which both depend on the building's orientation, will cause this figure to vary. Wind destroys the exterior "air film" on the glass, causing the U value of the window to increase. Shutters, screens, trees and other shielding devices will partially reduce this wind effect.

It is often easier to add storm windows than to change to double glazing in the original frame. The choice will vary with the physical conditions, the present needs and replacement plans, etc., for each building. Storm windows may greatly reduce heat transfer through windows because of the greater air space, and they give more control over air infiltration because of the second frame set tightly in the window opening.

Caulking to seal cracks or spaces in a structure, and weatherstripping of movable window sashes are the major means of reducing infiltration in the building envelope. There are probably as many types of caulking and weatherstripping materials as there are kinds of cracks to be filled.

In general, the best caulkings are nonhardening and surface-skinning. Caulkings must adhere permanently, and should be chosen to suit the surface. Surfaces must be clean and dry. A filler or backer-rod may be used for wide cracks. Weather-stripping types include compressible, closed cell, compressible "tubular" and interlocking metal strip systems. It is wise to get expert advice on choosing the most appropriate method/type for your building.

Heat gain through windows can have a major impact on energy use, depending on orientation, exposure, shading, season, types of glass, and glass treatment.

The effects of orientation are different for winter and summer. Winter sun allows a lot of midday solar heat gain on the south walls and into south-facing windows. Summer solar radiation, in contrast, is more severe on eastern and western exposures and not so serious on southern exposures. North-facing walls and windows get no sunshine in the winter, and only early morning and late afternoon angular exposure in the summer.

Exterior shading for windows must relate to these solar angles. On the east/west elevations, such devices must be vertical, the full height of the windows, sometimes adjustable for the actual orientation of the building and the time of day. For south-facing windows, roof overhangs and horizontal projecting "eyebrows" over each band of windows can be designed for complete summer shading, yet allow winter solar gains. If such shading devices are used, they are usually part of the original design and construction, but they can be added to a building.

External shading devices control solar heat gain most effectively because they prevent the sun from shining directly on the glass. There are some external louvered sun screens available which can be fixed to the window openings. Sometimes these sun screens can be removed to allow winter solar heat gain. Deciduous trees also provide good shade in summer and let sun in during the winter. Awnings can also be very effective.

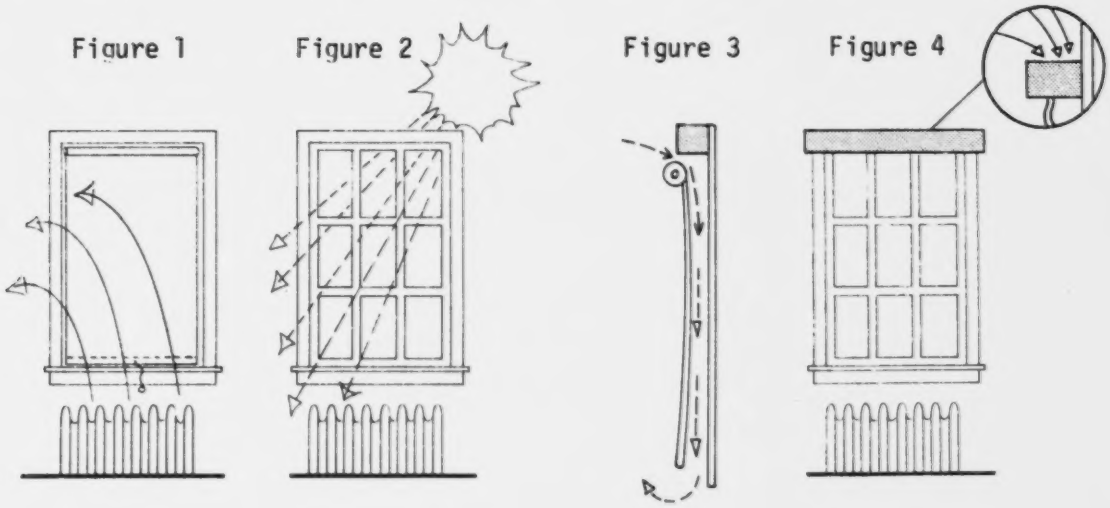
Tinted or reflective glass and reflective polyester films applied to the inside of the glass will reduce solar heat gain as well as heat loss. The tinted or reflective glass can be used to replace existing glass or to create double glazing (storm windows). The films are self-adhesive, but require special care in application. For storm windows, the film should be on the inner face of the outside layer of glass (do not put it on the inner glass or the reflected heat will be trapped).

An example of solar heat gain reduction was the application of reflective solar film to 10,000 square feet of east, south, and west windows in a 10-story office building in Miami, Florida. The annual energy savings was 15 percent with a payback of just over two years.

In winter, solar heat gain is beneficial, and its usefulness must be balanced against solar gains in the summer, according to orientation, types of glass, reflective films, latitude, solar control devices and percentage of sunshine. Note that about 10 percent less sunlight penetrates double glazing than single glazing. However, double glazing reduces the heat load due to conduction, and the benefits from this more than offset the loss of solar radiation.

Using Window Shades and Valances: Two Easy Ways to Save Energy

Figure 1 Figure 2 Figure 3 Figure 4



Windows are the "weak link" in the building shell, because heat flows easily through glass. Many agencies cannot afford to install double glazed or storm windows. Taping plastic sheets over the glass limits a window's usefulness, and besides, is singularly ugly. Window shades are an inexpensive solution to the problem of heat flow through windows.

A tightly fitting window shade, drawn to the sill, acts very much like a storm window -- it traps air between the glass and the shade, and thus prevents heat movement (air is an excellent insulator). Tests have proven that shades can reduce heat loss through windows by upwards of 35 percent. They are far more efficient than drapes or venetian blinds. In fact, drapes can actually increase the cooling of inside air in cold weather. (See Figure 1 and 2.)

In winter, if drapes are loosely hung from a window, air behind the drapes will chill. As the air chills, it begins to fall, and is replaced by warmer air from above, which also chills and falls. A circular air movement pattern, which actually cools the room, is established. (See Figure 3.)

This circular pattern can be interrupted by placing a valance or cover over the top of the curtain rods. This will keep air from "falling" behind the curtain. Another solution might be to install shades, mounted inside the window frame, in addition to a valance. (See Figure 4.)

Of course, shades should not be pulled down indiscriminately. In winter, you want the sun to warm the rooms of the agency. Once the sun has moved, or as dusk approaches, lower the shades. But in summer, a fully drawn window shade keeps out about half the heat (both solar and air) that would enter the building through an unshaded window. Heat and airconditioning costs can be reduced simply by lowering and raising shades at proper times, or by adding valances where curtains are used.

Heat Flow through Walls, Roof, Floors

The basic structural materials of most walls and roofs are inadequate as thermal barriers, and various amounts and types of insulation are included in their design. When you examine the building envelope in the Facility Audit, analyze the plans, details and specifications of its construction to determine the resistance to heat flow of its many parts. Do this for the various details of wall and roof construction, and for any floors over unconditioned spaces (crawl spaces, vented and unvented; pipe and mechanical spaces; rough storage spaces; outdoor spaces).

In the South, heat gain in summer will be more of an energy concern than heat loss in winter, but there are enough variables to consider that this should be determined for each situation. These variables include latitude, solar radiation, summer cooling degree days, winter degree days, building and wall orientation, surface heat absorption coefficients, seasonal wind patterns and velocities, as well as the theoretical U value of each building.

Walls

The mass of a wall does not guarantee a low U value. Mass simply provides a form of thermal inertia: it slows the heat transfer and delays the impact of outdoor temperature changes on the inside conditioned space. The time delay allows the wall to act dynamically as a thermal storage system, smoothing out peaks in heat flow and somewhat reducing yearly heat loss.

Increasing wall insulation is one method which might be considered to lower the U value in order to conserve energy. But, it is seldom possible to do this without going to some extreme measure, such as removing the interior wall surfaces (gypsum board or plaster, usually) and adding high R value insulation before resurfacing the walls.

A vapor barrier must be added with insulation. Inside the building, water, in the form of vapor, migrates through walls, floors, and ceiling to the cold exterior. Without a barrier, this water will condense inside the walls and cause extensive water damage. Some insulation types can be purchased with a vapor barrier; others form their own vapor barrier. Consult local suppliers for more information.

Insulation is available in three recommended forms:

1. Loose fill is normally poured by hand or blown into wall and ceiling cavities. The vapor barrier is always separate.

2. Batts and blankets are used between exposed wall studs and ceiling joists. Batts are pre-cut while blankets come in continuous rolls. They can be purchased with or without a vapor barrier.

3. Rigid board, depending on the material, can be used to insulate interior or exterior walls, basement walls, ceilings and roofs.

It is also possible to add insulation by putting a new facing over existing surfaces. When added to the exterior, the treatment will have to be weather-sealed and vaporproofed. It will give an entirely new look to the building unless the new facing is similar to the old. Such exterior treatment is feasible for low-rise structures, but difficult for tall buildings. It causes little disruption inside during installation.

It is easier to use interior insulation for tall buildings, but installation disrupts normal operations. In either case, there are likely to be architectural and mechanical complications not readily clear, and there are usually building code conditions to consider, so it is advisable to get competent professional help.

Roof

Heat gain and loss through the roof can also be reduced by lowering the U value by adding insulation. Again, there are techniques for this additional treatment, both on top of the roof and on the underside.

When adding insulation on top of the roof, the work is less disruptive and may be timely if the existing surface needs repair. The surface must be prepared according to the technique used. A professional should be consulted to help decide which type of insulation is best for your facility.

Insulation can be added below the roof by applying fitted pieces of insulation board. The complications of working above and around utility lines, pipes, ducts and structural members will have to be taken into account. The need to insulate pipes, ducts, etc. should not be overlooked, nor should their location in the attic allow some area of the roof underside to go untreated. If the insulation is laid over the existing ceiling, it is especially important to consider pipe and duct insulation and possibly the need for attic ventilation.

As a rule of thumb, the inches of duct insulation required equals one-fifteenth of the temperature difference between the conditioned air inside the duct and the unconditioned air in the attic space.

Floors

When floors over unconditioned spaces have inadequate resistance to heat flow, the U value can be lowered by adding insulation materials. Types of treatment will vary with accessibility. Where concrete floors are poured on grade, additional floor insulation can be added as an exterior perimeter treatment of insulation board placed against the foundation, from the bottom of the outer wall facing down to a point approximately 24 inches below grade.

Internal Heat Flow

Agencies are often housed in complex facilities that include many programs and services, and as a result are often zoned both functionally and mechanically into a number of related areas. Occasionally the temperature, humidity and

air movement requirements of these zones must be isolated or separated. Sometimes there is a contrast in the environments of two adjacent areas because one is "shut off" momentarily or temporarily. Under these conditions there may be a need for energy conservation measures due to air leakage or heat flow through inadequate barriers.

Air leakage is the more serious of these two types of heat gain and loss, and the harder to treat completely. Besides door cracks and leakage around electrical and utility boxes in walls, there are various types of ceiling penetrations -- recessed lights, airconditioning grilles, etc. -- which need seals in certain situations.

Acoustical tile "lay-in" ceilings are used in many buildings, including corridors in mechanically zoned areas. These ceilings are not air tight, and furthermore, are often used to create plenum spaces for return air systems with open grilles for air flow. They may allow more heat gain and loss than is suspected through inside structural openings. Such openings may be above walls which stop short of the structure; or they may be uncaulked penetrations of walls, slabs, shafts, chases, etc., for pipes, ducts, conduit and special function services. Many types of wall penetrations above ceilings cannot be seen.

The mechanical systems engineer for the building may be the first to suspect energy losses through such hidden paths of internal leakage, since they may be causing imbalances in the systems. Such leakage should be investigated by the mechanical systems engineer and by the maintenance staff, both on a "suspicion" basis, and in the basic Energy Audit of the building.

Conductive heat flow through walls, floors, ceilings and other internal barriers will be of concern only when an area is much hotter or much colder than the adjacent space. Such conditions should be anticipated by the building staff, especially the mechanical systems engineer and the energy management team. Be prepared to plan to control air leakage, even to install additional insulation.

Caution: Energy Conservation May Be Hazardous to Your Clients' Health

Improving a facility's energy efficiency is an important goal, and one that must be pursued, if for nothing else than the agency's economic survival. However, like so many well-intentioned actions in our society, energy conservation can have unintended, negative consequences.

An agency building, which may look very solid, is really quite porous. Air leaks into buildings where pipes pass through basement walls, through dampers that don't really close, and through windows and doors that aren't properly weatherstripped or sealed. A building might have a complete air change every hour, just from infiltration, even though windows are closed and the mechanical ventilation system is turned off. Some amount of infiltration is desirable and healthy. As we weatherstrip and caulk, close and secure dampers, and limit the air flow into buildings, we can create a new problem: internal air pollution.

Unlike outdoor pollution, which is caused by car exhausts, utilities, and factories, indoor pollution originates in activities and materials within the facility itself. The pollutants:

FORMALDEHYDE, used as a bonding agent in foam insulation (the type that is injected into walls), also used in furniture, plywood, particle board, and carpeting adhesive. The Consumer Product Safety Commission has voted to propose a ban on the future use of urea-formaldehyde (UF) foam insulation in all buildings.

NITROGEN DIOXIDE, and CARBON MONOXIDE, which come primarily from gas stoves and heaters.

SOOT and PENZOPYRENE, from cigarette smoke.

RADIOACTIVE RADON, a natural constitute of stone, soil and water, seeps into basements and can concentrate there. As it decays, radon produces "offspring," i.e., polonium, lead, and bismuth, which are chemically active, and can collect in lungs if inhaled.

What to Do

First, do not, under any circumstances, use urea-formaldehyde foam insulation. It can cause rashes, nosebleeds, and vomiting. Children are especially sensitive to it. Certain states have entirely banned its use.

Second, you might install an air to air heat exchanger. Heat exchangers have been used for years in Scandinavian countries, where cold climates demand that buildings be well-sealed. They are basically simple devices that pull fresh air in and blow stagnant air out through separate ducts on a common wall. As the two air streams pass, in opposite directions, the common wall allows the cool air to absorb the stagnant air's heat which is on its way out of the building. Heat wheels can accomplish this goal as well, although installation is more expensive.

Sufficient ventilation can also be achieved by opening all rooms or windows daily to allow an exchange of building air. Though the air will be cooled, the furniture, walls, etc. will retain their warmth, so the building or rooms will quickly reheat.

Another major energy/health concern is the susceptibility of the elderly to hypothermia.

Hypothermia is a slow decline in body temperature. The main problem is that its victims may not even feel a chill. As people age, their "control mechanisms" deteriorate, and do not "know" that the body is cold. Once body temperature falls below 94°F (98.6°F is normal), it can keep falling, even if the person has moved to a warmer area. Hypothermia can be triggered by indoor temperatures as "warm" as 60°F to 65°F. Agencies which service the elderly should maintain a temperature of no less than 68°F in areas of elderly activity.

Children are also vulnerable to cold, but in a different way. Child activity is often floor centered. Children roll, climb, play, and sit on the floor, rather than use furniture. Often the floor covering is vinyl tile over poured concrete. A cold floor (which has a large thermal mass) may simply draw body heat from a child, who may not even feel cold since the air is not cold. Rugs and carpeting are the best surface for a children's play area -- and carpeting is often easier to maintain than vinyl tile.

Determining Roof and Wall U Values

The chart below enables an agency to determine the U value of its building's roof and walls, and to make an intelligent "guesstimate" if not enough information is available.

To use the table, moving from left to right, select the best characteristic from each column most appropriate to your facility. If you cannot determine the exact insulation, use the underlined information. For example, if you have a roof with one-inch thick wooden decking, and you know there are two inches of rigid insulation beneath it, use the appropriate U value -- in this case, 0.14. If you don't know what is underneath, the most likely or intelligent guess would be that it has up to 1.5 inches of rigid insulation (the underlined value) -- and that's what you should enter on the audit forms, with the appropriate U value (0.22).

I. ROOF CODES

Decking Material	Ceiling	Insulation	Actual U value
Wood			
1" thickness	No suspended ceiling	None	0.42
		Rigid	
		Up to 1.5"	0.22
		1.5" to 2.5"	0.14
		2.5" and up	0.11
	Suspended ceiling	None	0.23
		R-11 batts	0.07
		Rigid	
		Up to 1.5"	0.15
		1.5" to 2.5"	0.11
		2.5" and up	0.09
2" thickness	No suspended ceiling	None	0.28
		Rigid	
		Up to 1.5"	0.17
		1.5" to 2.5"	0.12
		2.5" and up	0.10
	Suspended ceiling	None	0.18
		R-11 batts	0.06
		Rigid	
		Up to 1.5"	0.13
		1.5" to 2.5"	0.10
		2.5" and up	0.08
Mineral Fiber (e.g. tectum)			
2" thickness	No suspended ceiling	None	0.21
		Rigid	
		Up to 1.5"	0.17
		1.5" to 2.5"	0.12
		2.5" and up	0.10

Decking Material	Ceiling	Insulation	Actual U value
Mineral Fiber			
2" thickness	Suspended ceiling	None	0.15
		R-11 batt	0.06
		Rigid	
		Up to 1.5"	0.13
		1.5" to 2.5"	0.10
		2.5" and up	0.08
3" thickness	No suspended ceiling	None	0.15
		Rigid	
		Up to 1.5"	0.11
		1.5" to 2.5"	0.09
		2.5" and up	0.07
	Suspended ceiling	None	0.15
		R-11 batt	0.05
		Rigid	
		Up to 1.5"	0.09
		1.5" to 2.5"	0.08
		2.5" and up	0.06
Metal Decking	No suspended ceiling	None	0.90
		Rigid	
		Up to 1.5"	0.32
		1.5" to 2.5"	0.18
		2.5" and up	0.13
	Suspended ceiling	None	0.32
		R-11 batt	0.07
		Rigid	
		Up to 1.5"	0.19
		1.5" to 2.5"	0.13
		2.5" and up	0.10
Concrete			
(Note: If weight cannot be determined, use HEAVYWEIGHT for facilities built prior to 1960 and LIGHTWEIGHT for facilities built 1960 to present.)			
Lightweight (up to 100 pcf) (including formboard)	No suspended ceiling	None	0.22
		Rigid	
		Up to 1.5"	0.15
		1.5" to 2.5"	0.11
		2.5" and up	0.09
	Suspended ceiling	None	0.15
		Rigid	
		Up to 1.5"	0.11
		1.5" to 2.5"	0.09
		2.5" and up	0.07

Decking Material	Ceiling	Insulation	Actual U value
Concrete			
Heavyweight (over 100 pcf) (including formboard)	No suspended ceiling	None	0.52
		Rigid	
		Up to 1.5"	0.27
		1.5" to 2.5"	0.16
		2.5" and up	0.11
	Suspended ceiling	None	0.26
		Rigid	
		Up to 1.5"	0.17
		1.5" to 2.5"	0.12
		2.5" and up	0.09
Pitched Roofs With Attics (shingle, asphalt shingle or clay tile roofing)			
No inside sheathing		None	0.48
Inside sheathing		None	0.28
		R-9 batts	0.09
		R-11 batts	0.07

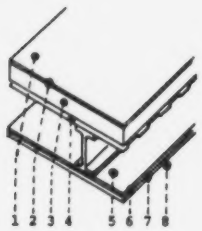
II. WALL CODES

Basic Wall Construction	Insulation	Actual U value
Solid Brick		
8" thick, no cavity, plaster interior	None	0.33
	Insulating board	0.20
8" thick, no cavity, lath and plaster	None	0.26
12" thick, no cavity, plaster interior	None	0.30
	Insulating board	0.17
12" thick, no cavity, lath and plaster	None	0.22
Brick on Concrete Block		
8" block, no cavity	None	0.30
with 1" air space	None	0.23
	Insulating board	0.17
	Vermiculite fill	0.12
4" block, no cavity	None	0.36
with 1" air space	None	0.27
	Insulating board	0.19
	Vermiculite fill	0.17

Basic Wall Construction	Insulation	Actual U value
Concrete Block		
8" block	None	0.48
	Vermiculite fill	0.15
	Rigid	
	Up to 1.5"	0.26
	1.5" or more	0.14
12" block	None	0.45
	Vermiculite fill	0.12
	Rigid	
	Up to 1.5"	0.20
	1.5" or more	0.13
Brick Veneer on Wood or Steel Stud	None	0.32
	R-7 batts	0.10
	R-9 batts	0.08
Wood Siding on Wbod or Steel Studs	None	0.30
	R-7 batts	0.10
	R-9 batts	0.08
Stucco on Wood or Steel Studs	None	0.40
	R-7 batts	0.11
	R-9 batts	0.09
Curtain Wall, Storefront or Insulated Panels	None	1.11
	Rigid	
	Up to 1.5"	0.20
	1.5" or more	0.16
Solid or Tilt-Up Concrete, Sandwich Panels		
4" to 6" thick	None	0.78
	Rigid	
	Up to 1.5"	0.25
	1.5" or more	0.15
8" or thicker	None	0.55
	Rigid	
	Up to 1.5"	0.22
	1.5" or more	0.14

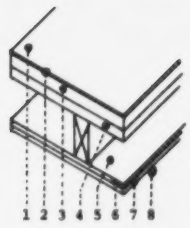
U values for Typical Wall and Roof Construction

ROOFS

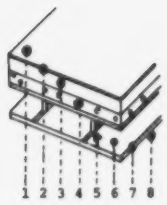


Example

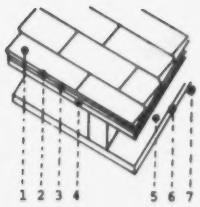
Construction	Resistance (R)
1. Outside surface (15 mph wind)	0.17
2. Built-up roofing (3/8 inch)	0.33
3. Roof insulation (C=0.24)	4.17
4. Metal deck	0.00
5. Air space	0.99
6. Metal lath and	
7. 3/4 in. plas. (sand agg.)	0.13
8. Inside surface (still air)	0.92
Total resistance	6.71
U=1/R=1/6.71	0.15



(Heat flow up)	
1. Outside surface (15 mph wind)	0.17
2. Built-up roofing (3/8 inch)	0.33
3. Roof insulation (C=0.72)	1.39
4. Plywood deck (5/8 inch)	0.78
5. Air space	0.85
6. Gypsum wallboard (1/2 inch)	0.45
7. Acoustical tile (1/2 inch) glued	1.25
8. Inside surface (still air)	0.61
Total resistance	5.83
U=1/R=1/5.83	0.17

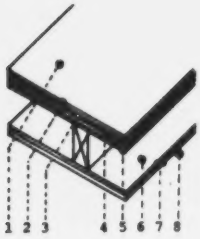


(Heat flow up)	
1. Outside surface (15 mph wind)	0.17
2. Built-up roofing (3/8 inch)	0.33
3. Roof insulation (none)	--
4. Concrete slab (lt. wt. agg. 2 in.)	2.22
5. Corrugated metal	0.00
6. Air space	0.85
7. Metal lath and 3/4 in. plas. (lt. wt. agg.)	0.47
8. Inside surface (still air)	0.61
Total resistance	4.65
U=1/R=1/4.65	0.22



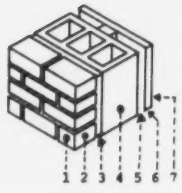
(Heat flow up)	
1. Outside surface (15 mph wind)	0.17
2. Asphalt shingle roofing	0.44
3. Building paper	0.06
4. Plywood deck (5/8 inch)	0.78
5. Air space (3.5 in. reflective surf.)	2.06
6. Gypsum wallboard (1/2 inch)	0.45
7. Inside surface (still air)	0.62
Total resistance	4.58
U=1/R=1/4.58	0.22

Example

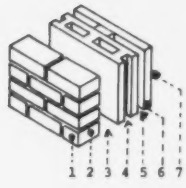


Construction (Heated room below unheated space) (Heat flow up)	Resistance (R)
1. Top surface (still air)	0.61
2. Linoleum or tile (avg R)	0.05
3. Felt	0.06
4. Plywood (5/8 inch)	0.78
5. Wood subfloor (3/4 inch)	0.94
6. Air space	0.85
7. Metal lath and 3/4 in. plas. (lt. wt. agg.)	0.47
8. Bottom surface (still air)	0.61
Total resistance	4.37
U=1/R=1/4.37	0.23

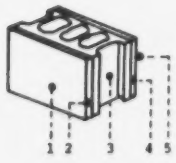
WALLS



1. Outside surface (15 mph wind)	0.17
2. Face brick (4 inch)	0.44
3. Cement mortar (1/2 inch)	0.10
4. Concrete block (cinder agg.)(8 in.)	1.72
5. Air space (reflective)	2.80
6. Gypsum wallboard, foil back(1/2 in)	0.45
7. Inside surface (still air)	0.68
Total resistance	6.36
U=1/R=1/6.36	0.16



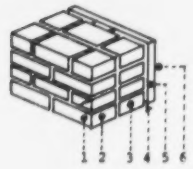
1. Outside surface (15 mph wind)	0.17
2. Common brick (4 inch)	0.80
3. Air space	0.97
4. Concrete block (stone agg.)(4 in.)	0.71
5. Air space	0.97
6. Gypsum wallboard (1/2 inch)	0.45
7. Inside surface (still air)	0.68
Total resistance	4.75
U=1/R=1/4.75	0.21



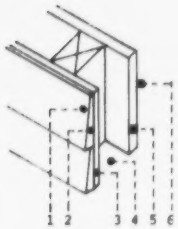
1. Inside surface (still air)	0.68
2. Plas. (lt. wt. agg.)(5/8 inch)	0.39
3. Cement block (cinder agg.)(4 in.)	1.11
4. Plas. (lt. wt. agg.)(3/4 in.)	0.39
5. Inside surface (still air)	0.68
Total resistance	3.25
U=1/R=1/3.25	0.31

Example

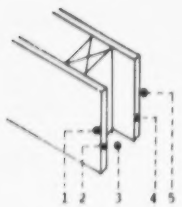
WALLS



Construction	Resistance (R)
1. Outside surface (15 mph wind)	0.17
2. Face brick (4 inch)	0.44
3. Common brick (4 inch)	0.80
4. Air space	0.97
5. Gypsum wallboard (1/2 inch)	0.45
6. Inside surface (still air)	0.68
Total resistance	3.51
U=1/R=1/3.51	0.29**



1. Outside surface (15 mph wind)	0.17
2. Siding, wood, 1/2 in. X 8 in. lapped (avg)	0.81
3. Sheathing, 1/2 in. asphalt impregnated	1.32
4. Air space	0.97
5. Gypsum wallboard (1/2 inch)	0.45
6. Inside surface (still air)	0.68
Total resistance	4.40
U=1/R=1/4.12	0.23



1. Surface (still air)	0.68
2. Gypsum board (1/2 inch)	0.45
3. Air space	0.97
4. Gypsum wall board (1/2 inch)	0.45
5. Surface (still air)	0.68
Total resistance	3.23
U=1/R=1/3.23	0.31

**Adjustment for furring (1 X 2 in. @ 16 in. o.c.)
= U X 1.00 = 0.29 X 1.00 = 0.29

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TABLE 1: THICKNESS OF INSULATION PER R-VALUE

R—VALUES										
	BATTS or BLANKETS		LOOSE FILL (POURED-IN)			RIGID PLASTIC FOAMS			
	Glass Fiber	Rock Wool	Glass Fiber	Rock Wool	Cellulosic Fiber	Urethane	U-F	Styrene	
R-11	3½"-4"	3"	5"	4"	3"	1½"	2"	2¼"	R-11
R-13	4"	4½"	6"	4½"	3½"	2"	2½"	2¾"	R-13
R-19	6"-6½"	5¼"	8"-9"	6"-7"	5"	2½"	3¾"	4¼"	R-19
R-22	6½"	6"	10"	7"-8"	6"	3"	4"	4½"	R-22
R-26	8"	8½"	12"	9"	7"-7½"	3¾"	5"	5½"	R-26
R-30	9½"-10½"	9"	12"-13"	10"-11"	8"	4½"	5¾"	6½"	R-30
R-33	11"	10"	15"	11"-12"	9"	4¾"	6½"	7¼"	R-33
R-38	12"-13"	10½"	17"-18"	13"-14"	10"-11"	5½"	7½"	8½"	R-38

See caution page 2-47.

HEATING ZONE MAP

TABLE 2

HEATING ZONE	RECOMMENDED FOR CEILING	WALL	FLOOR
0,1	R-26	R-13	R-11
2	R-26	R-19	R-13
3	R-30	R-19	R-19
4	R-33	R-19	R-22
5	R-38	R-19	R-22

Sources for R-value data include Federal Housing Administration, American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), and insulation manufacturers.

LIGHTING SYSTEM

Significant potential exists for modifying the lighting system in your facility. Many lighting systems were designed within the restrictions of initial cost economies, without knowledge of final space use and subdivision, and without the benefit of relatively recent developments and research findings. Modifications can reduce energy consumption (and associated costs) substantially, while still providing occupants with the required quality and quantity of illumination.

Before making any changes, you must recognize that a lighting system is just that -- a system. Its many elements are interrelated, just as the whole lighting system is interrelated with other systems in the building. While energy can be conserved by delamping -- removing lamps and luminaires -- such action should be taken only after the entire system has been analyzed and all options evaluated. Energy conservation programs are important, but they must be consistent with other facility requirements, including productivity and visual comfort, aesthetics and federal, state and local regulations.

It is important to recognize that major alterations to a lighting system can have a significant impact on heating and cooling systems, most of which were designed to consider the amount of heat given off by the lighting system. For these reasons, competent technical assistance should be obtained before any significant changes are made. Changes should be made only after considering the building's illumination needs, the lighting system that currently exists and after evaluating the many different options.

The next few pages consider some of the actions that might be taken to implement an effective program of lighting energy management.

For more information see:

Energy Conservation Standards, Chapter 9 (page 205). Also, TEM has a complete section on lighting (page 31), for background needed to complete the worksheets.

Reducing Energy Costs in Religious Buildings, which has a good, clear and concise section on lighting (page 29).

A Guide to Saving Lighting Energy Dollars, which is recommended for facilities that want to explore more fully savings possibilities.

How to Save Energy and Cut Costs in Existing Buildings, Section IX (page 231) for a discussion of conservation opportunities in the lighting system. A more technical discussion is found in Section XIX (page 523).

An excellent first step in a program of lighting management is to modify usage patterns based on factors identified by the Facility Audit. If you develop a lighting usage program, it will have to be updated and modified as changes are made to the lighting system, but for the most part such modifications should be relatively simple once the initial steps have been taken.

A lighting usage program can be implemented inexpensively and quickly. It can be designed to meet the needs of building occupants. The key element of a lighting usage program is a lighting schedule set up according to occupancy patterns. Personnel should be assigned, trained and made responsible for the efficient use of lighting by means of the lighting control schedule.

Define the exact nature of occupancy for each time period. Determine the amount of lighting needed for safety and security purposes. Provide detailed instructions to responsible employees for system operation by means of charts, posting and/or color coding of switches. These employees must be well trained to assure understanding and compliance with the procedures.

The agency energy management coordinator may wish to purchase a light meter (for about $30), to check the agency lighting levels against these recommended levels. These levels may or may not be appropriate for your agency, but they will help the energy management team make more intelligent decisions about the agency's lighting needs. Some utilities provide guidance in the use of a light meter and how to apply the information gathered. It is worth contacting the local utility company to investigate its services.

Representative Illumination Levels on Task

Area or Task	Recommended foot-candles
Reading printed materials	30
Reading pencil writing	70
Drafting, benchwork	100
Lip reading, chalkboards, sewing	150
Art rooms	70
Lecture rooms - audience area	70
- demonstration area	150
Shops	100
Sight-saving rooms	150
Dormitories	10
Accounting offices	150
General offices - typing	70
- reading poor reproductions	150
- reading fair reproducings, filing	100
Conference rooms - critical seeing tasks	100
- conferring	30
Lobby (or entrance foyer)	50
Corridors, stairways, locker rooms	20

Source: Illumination Engineering Society, "IES Lighting Handbook." These standards currently being revised. Contact IES, 345 East 47th Street, New York, N.Y. 10017 for updated standards.

SOME BASICS ABOUT AVAILABLE LIGHT SOURCES

Lamps come in a variety of types having differing life spans, color rendition capabilities, efficiencies and costs to purchase and operate. All of these factors are important in choosing the proper lamp for the task.

The measure of light source efficiency is lumens per watt -- or, the yield of light output (measured in lumens) for the energy expended (measured in watts). This is similar to the miles per gallon amount used to judge the efficiency of cars: the higher the number, the more efficient the light source. Efficiencies vary with lamp size and type, and generally increase with wattage.

The more familiar incandescent, fluorescent and mercury vapor lamps operate at lower efficiency levels than the newer metal halide and sodium vapor lamps. The relative efficiency of common light sources is compared in the following pages.

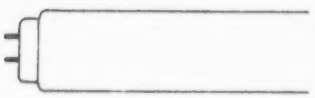
If energy consumption and life span were the only considerations, the more efficient metal halide and sodium lamps would be preferred for their low operating cost and relatively long lamp life. However, there are other factors, such as color rendition, fixture and lamp cost, to be taken into account. Each light source is discussed below in relation to these considerations.

Incandescent lighting is inexpensive to install on a "per fixture" basis, although the greater number of fixtures usually required often offsets the savings. Because of a very short lamp life, incandescents must be replaced often, resulting in high labor and lamp costs. These lamps are the least energy efficient lamps available. Color rendering properties are excellent, but for most applications, other color corrected sources are also acceptable (Color rendition of all lamps is measured using incandescents as the standard.)

Typical lumens per watt: lamp only = 20

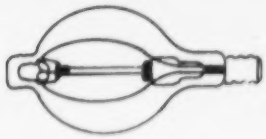
Mercury lamps are often preferred to incandescents for their significantly longer life (up to 24,000 hours). Improved color phosphor-coated lamps have adequate color rendition, although not as good as incandescent or color-corrected fluorescents. Mercury lamps are somewhat more efficient than incandescents.

Typical lumens per watt: Self-ballasted = 25; Standard: lamp only = 63, including ballast = 58



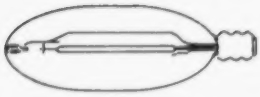
Fluorescent lighting has been improved in recent years. It can have good color rendition and long lamp life, and it is reasonably efficient. Many types of fixtures (luminaires) are available in all price ranges; newer varieties have considerable architectural appeal. Fluorescents are usually more costly to install than incandescents, but are much less expensive to operate, both from an energy and maintenance viewpoint.

Typical lumens per watt: lamp only = 100; incl. ballast = 85



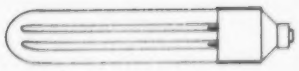
Metal halide (Metalarc) lighting is growing in popularity due to its advantages over most other sources. Fixtures and lamp costs are comparable to mercury vapor but, because of the greater efficiency of metal halide, fewer fixtures are usually needed. Lamp life, not as long as mercury at present, is improving as a result of research. Metal halide lamps have approximately the same color rendition capability as mercury. They are particularly suited to lighting large high spaces.

Typical lumens per watt: lamp only = 125 including ballast = 115



High pressure sodium (HPS) lamps, with their distinctive salmon color, are becoming a familiar sight on many community streets. They equal or surpass mercury vapor or metal halide lamps in energy efficiency. Although color rendition capability is far from perfect, it is adequate for parking areas and, when mixed with a small number of other light sources for certain indoor uses.

Typical lumens per watt: Standard (Lumalux): lamp only = 140, incl. ballast = 127; Easy start (Unalux): lamp only = 116, incl. ballast = 97



Low pressure sodium is the most energy efficient light source commercially available. These lamps have acceptable lifespans, and there is a limited range of inexpensive fixtures. Color rendition is very poor, as it is almost impossible to distinguish colors under a low pressure sodium bulb because the light produced by this source is only one color (light that gives color rendition itself consists of many colors mixed together).

Typical lumens per watt: lamp only = 183; including ballast = 150

Possible agency conversion strategies would be:

1. incandescent to more efficient incandescents: These should be used where ambient quality is important and/or no changes in fixtures can be made.
2. incandescent to fluorescent: This should be done wherever possible, except where high efficiency lights can be used (see below).
3. incandescent or fluorescent to high pressure sodium (HPS): HPS should be used in high ceiling spaces, such as gym and natatorium.
4. mercury vapor or metal halide to low pressure sodium (LPS): LPS should be used in areas such as parking lots.

BASIC FLUORESCENT LAMP SELECTION GUIDE

TYPE	CHARACTERISTICS	RELATIVE EFFICIENCY	SUGGESTED AREAS OF USE, AGENCY & NONAGENCY
Cool White	Produces neutral to fairly cool atmosphere, similar to midafternoon daylight. Most widely used.	100%	General work areas in agency facilities, offices; industry and general commercial spaces.
Deluxe Cool White	Simulates natural daylight. Atmosphere comparable to Cool White. Very good color rendition.	69%	Areas in which color rendition is critical: merchandising and food service areas, display areas; decorator designed areas, such as private offices and conference rooms.
Warm White	Blends with incandescent light; produces warm, incandescent-like atmosphere.	100%	General work areas where slightly warmer atmosphere than Cool White is desired.
Deluxe Warm White	Simulates incandescent light. Good color rendition.	68%	Principal fluorescent lamp for use in homes or where it is to blend with incandescent. Residential areas, assembly, dining and office areas where warm atmosphere is desired.

VENTILATION, HEATING AND COOLING SYSTEMS

Ventilation

Ventilation contributes to heat gain or heat loss (and humidification and dehumidification), depending on the season. The ventilation system provides a building with fresh air by exchanging inside air for outside air. The rate of ventilation is expressed in cubic feet per minute (cfm) or in air changes per hour. The greater the rate of air exchange, the more heating or cooling is required to offset the heat loss or heat gain caused by the unconditioned air that is brought into the building. In many instances, the single most dramatic area of energy conservation -- and one achieved at virtually no expense -- involves reducing a ventilation rate which may be set far above actual requirements.

Heating and Cooling

The largest energy users in most buildings are the heating and cooling systems. It is no secret that when energy was inexpensive, equipment was often oversized and inefficient.

Your facility's total heat loss is equivalent to the amount of heat that the heating system must add to the space (in a given time) to maintain a given temperature. Infiltration imposes a significant load on the heating and cooling systems, which increases total energy consumption.

Your facility's total heat gain is the amount of heat that the cooling system must remove from the space (in a given time) to maintain a given temperature.

In most cases, those factors which contribute to heat loss and heat gain can be modified.

Three categories of heating and cooling affect each system and its efficiency. They are:

1. Maintenance modifications. The importance of routine equipment maintenance to your energy management program cannot be overemphasized. Regular maintenance will extend the useful life of equipment, save you energy dollars and provide better service.

2. Systems modifications. Each system interacts with the others in a building. Although modifications of inefficient systems are encouraged, a careful analysis by a trained engineer should precede any actual system changes.

3. Control adjustments. Your building's original controls were probably chosen more on a cost basis than on an energy conserving basis. Lack of proper maintenance can result in a decrease in sensitivity.

Building Heating Loads

The principal factor that determines the building heating load is the average difference between indoor and outdoor temperatures; the larger the temperature difference, the greater the load. You can reduce the load by maintaining lower indoor temperatures for as long a period as possible during the heating season. Lowering the temperature to 68°F or less in the major areas of the building when it is occupied, and maintaining even lower temperatures in less critical areas will conserve energy. The amount of heat produced internally by lights, people and business machines (internal heat gains) and the amount of sunlight shining on the building and transmitted through windows and doors also reduce the building heating load.

Realize greater savings by reducing the indoor temperature at night and during weekends. Outdoor temperatures are generally lower at night, and neither solar heat gain nor internal heat gain helps to offset nighttime heat loss.

The amount of air introduced for ventilation, or which infiltrates through the building envelope also contributes to the heating load. This air must be heated and humidified to meet indoor conditions. Its ultimate effect on the load depends, as with other heating loads, on the difference in indoor and outdoor temperatures and the quantity of outdoor air. In cold climates, shutting off ventilation air at night may result in your single largest energy savings.

Building heat load also depends on the amount of moisture maintained in the building. Relative humidity is the measure of the moisture content in the air. When cold outdoor air enters the building by ventilation and infiltration, the relative humidity of the interior of the building drops, and additional moisture, in vaporized form, must be added. Vaporization requires energy in the form of heat. The greater the volume of outdoor air, the greater is the heat demand to supply humidification. Lowering the level of humidification conserves energy.

A building is more comfortable at lower temperatures if the relative humidity is maintained at a level within a range of 20 percent to 40 percent. In a "tight" building with little air leakage and a small amount of ventilation, the energy saved by lowering the temperature will exceed the energy required to maintain humidity levels above 20 percent. Since there is little medical knowledge to support the contention that relative humidities higher than 20 percent are healthier, it is recommended that you maintain a maximum of 20 percent relative humidity during the daytime in occupied areas of the building, and add no humidification at night.

Finally, the building envelope -- the roof, exterior opaque walls, windows and doors, all of which are subject to the impact of the outdoor climate -- influences the size of the building heating load. In addition to the effect of infiltration, heat is transmitted through the building envelope by conduction, depending upon the temperature difference between indoors and outdoors, and the resistance to heat transfer of each of the building components.

Building Cooling Load

Two components -- sensible or dry heat and latent heat, a function of the heat content of the moisture in the air -- determine the building cooling load. To maintain comfort, the dry bulb temperature which measures sensible heat, and the wet bulb temperature (or the relative humidity) which measures latent heat, must be controlled. Because air for most comfort cooling installations is dehumidified when it is cooled, separate control of the relative humidity is not usually required.

Average temperature difference between indoor and outdoor conditions is one of the factors that defines the sensible heat gain portion of the annual building load. You can reduce this load by maintaining higher indoor temperatures for as long as possible during the cooling season, whenever further operation of the mechanical refrigeration system would be required to maintain a lower one. When the sensible heat gain is decreased, reduce the amount of cool supply air accordingly to realize additional energy savings in fan horsepower.

The average difference in temperature between indoor and exterior surfaces of the walls and roof depends on outdoor dry bulb temperatures and the amount of solar radiation hitting the outside walls and roof and warming them to a level ("sol-air") temperature which is most often above ambient temperatures. To conserve energy, shut off the refrigeration system and its auxiliaries (chilled water and condenser water pumps, cooling towers and air cooled condensers) during unoccupied periods, and maintain a dry bulb temperature of 78°F or higher during occupied periods. Maintaining even higher temperatures in less critical space will conserve more energy. If the relative humidity in the building rises to 55 percent (the usual level is 45 percent to 50 percent), or fluctuates normally (within the limits set by the refrigeration system's ability to maintain wet bulb temperatures), considerable energy will be conserved. The system requires power to remove moisture which originates from internal loads -- people and cooking -- and from outdoor air as it infiltrates and/or ventilates the building.

Heat gain -- a term used to quantify the amount of heat which is added to a space and must be removed to maintain desired conditions -- increases the cooling load. Solar heat gain through windows is often a major portion of the sensible heat building cooling load. The benefits of using the sun to reduce the heating load in the winter are considerable, but remember to block it out in the summer.

Just as ventilation and infiltration add to the heating load in the winter, they also increase the cooling load in summer. Outside air must be cooled and dehumidified. Maintaining higher indoor temperatures and relative humidity both reduces the cooling load caused by infiltration and ventilation, and conductive heat gains. However, when outdoor air is cool enough to lower the indoor temperatures, using an economiser cycle to cool or precool the building at night, without mechanical refrigeration, will conserve energy. When the wet bulb temperature of the outdoor air is lower than the wet bulb temperature of the return air from the interior spaces, an enthalpy controller will open the outside air dampers and close the return air dampers to take in 100 percent outdoor air. The controller saves power for the refrigeration system. Internal heat gains -- heat emitted from electric lighting fixtures, business machines, motors, cooking equipment and people -- form a large part of the total cooling load.

Reducing the building cooling load by a fixed percentage allows further savings of energy since distribution of loads can be decreased accordingly. A reduction in the flow of cool air or chilled water to meet the reduced load and an increase in the suction temperatures at which the refrigeration chillers or compressors operate will result in significant savings -- less horsepower per ton of refrigeration (12,000 Btu's), as well as less tons to be produced.

Distribution System Loads

The distribution system may carry chilled water to units in the spaces to be conditioned (fan coil, induction, or small air handling units) or to remote air handling units (which supply air, via ducts, to local registers and diffusers). In some systems, the compressors discharge a vaporized refrigerant to a condenser, where it is condensed to a liquid; then it is allowed to expand directly in a cooling coil which cools or dehumidifies circulating air. In all cases, air may be circulated from the conditioned space, from outdoors or from a mixture of both. The air is supplied after it is filtered, cooled and dehumidified in the air handling unit or air handling section of the airconditioning system.

For more information see:

Energy Conservation with Comfort (pages 10-75), which is devoted primarily to understanding and modifying HVAC systems.

Energy Conservation Standards, Chapter 11 (page 259) on HVAC systems, Chapter 12 (page 303) on boilers and refrigeration, as well as Chapters 6 (page 99) and 7 (page 161) on heating and cooling.

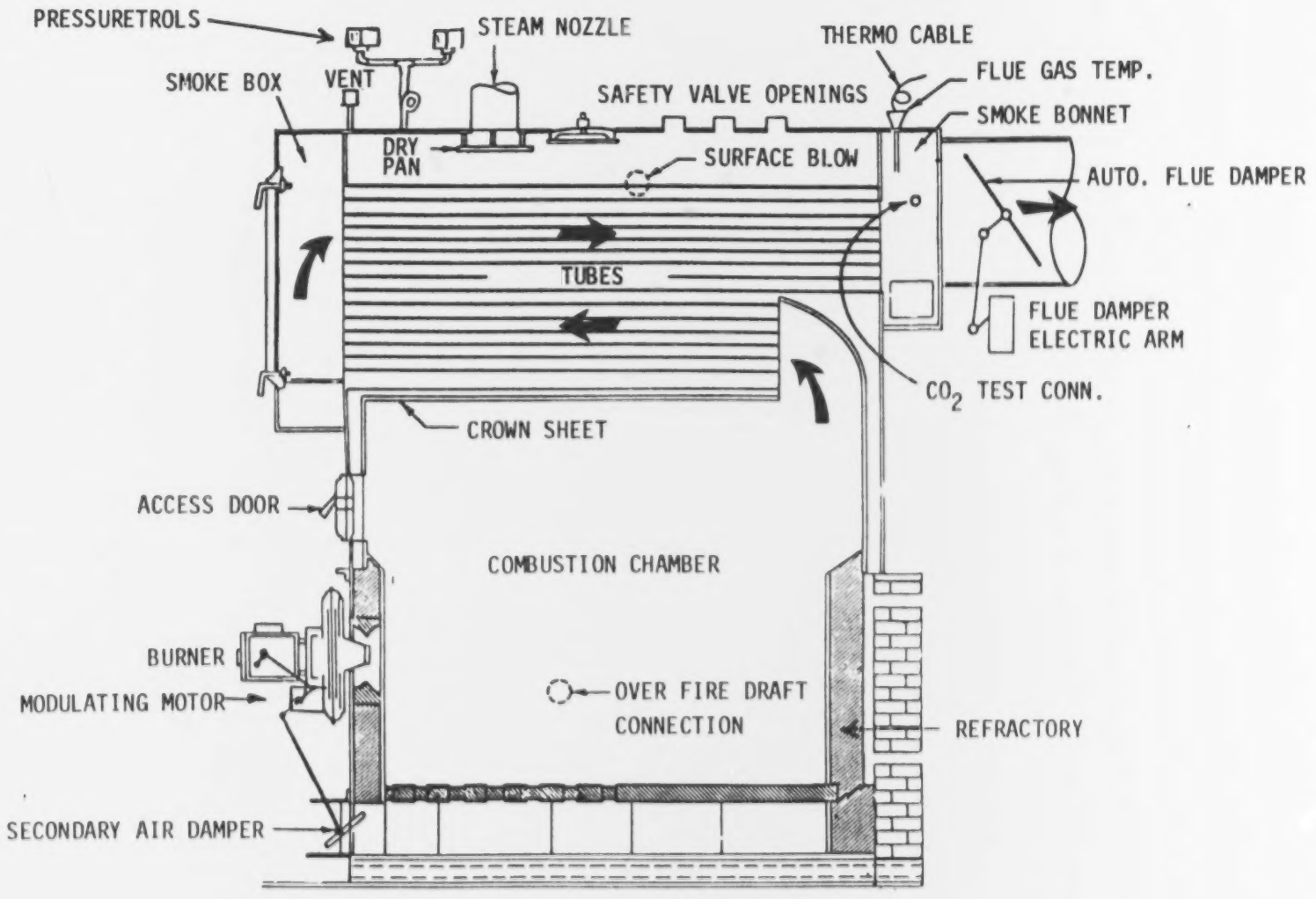
TEM section on ventilation (page 16), heating and cooling (page 18).

How to Save Energy and Cut Costs in Existing Buildings, for extensive information on HVAC systems, especially Sections Four (page 95), Six (page 153), Seven (page 189), Thirteen (page 303), Fifteen (page 405), and Seventeen (page 469).

Energy Management for Colleges and Universities, which discusses HVAC systems on pages 19-22, 34, 38-40, and elsewhere throughout the book.

Fundamentals of Boiler Efficiency, a 19-page book devoted entirely to explaining how boilers work.

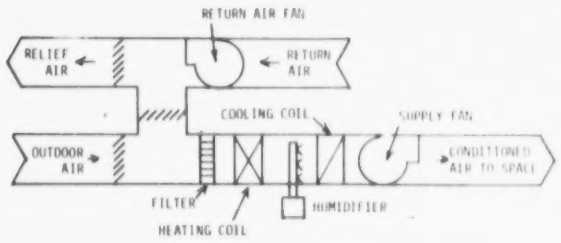
Most manuals have sections on HVAC systems. Consult the books in your energy management library.



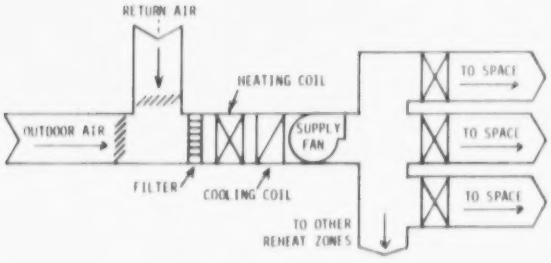
TYPICAL BOILER FEATURES

IDENTIFYING SYSTEMS

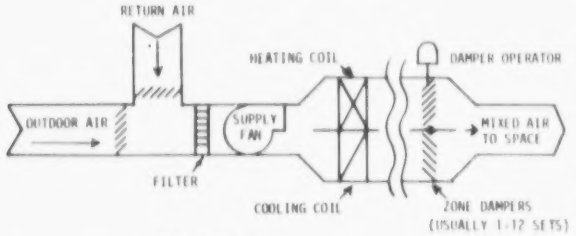
A variety of heating and cooling system types are mentioned throughout this manual. The following diagrams and descriptions are included to aid energy managers in identifying and understanding the systems that serve their buildings.



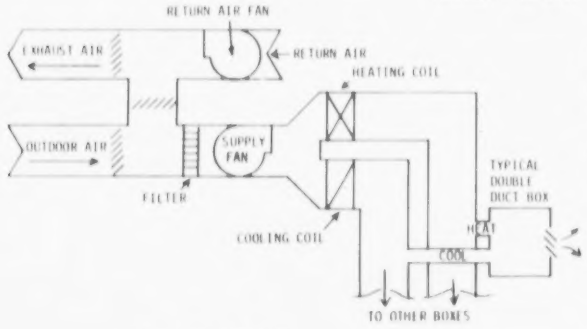
Single zone systems consist of a mixing, conditioning and fan section. The conditioning section may have heating, cooling, humidifying or a combination of capabilities. Single zone systems can be factory assembled roof top units or built up from individual components and may or may not have distributing duct work.



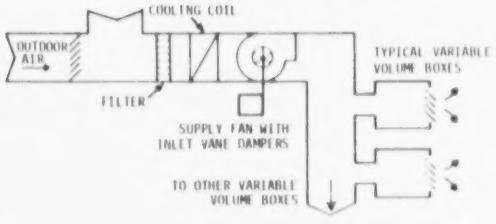
Terminal reheat systems are modifications of single zone systems. Fixed cold temperature air is supplied by the central conditioning system and reheated in the terminal units when the space cooling load is less than maximum. The reheat is controlled by thermostats located in each condition space.



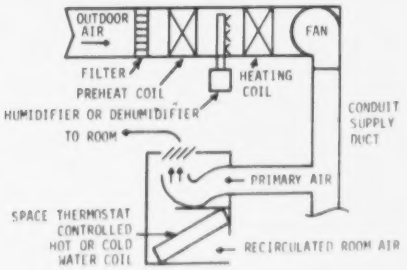
Multizone systems condition all air at the the central system and mix heated and cooled air at the unit to satisfy various zone loads as sensed by zone thermostats. These systems may be packaged roof top units or field fabricated systems.



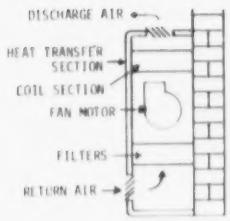
Dual duct systems are similar to multizone systems except heated and cooled air is ducted to the conditioned spaces and mixed as required in terminal mixing boxes.



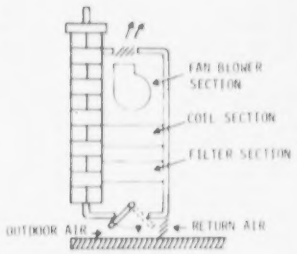
Variable air volume systems deliver a varying amount of air as required by the conditioned spaces. The volume control may be by fan inlet (vortex) damper, discharge damper or fan speed control. Terminal sections may be single duct variable volume units with or without reheat, controlled by space thermostats.



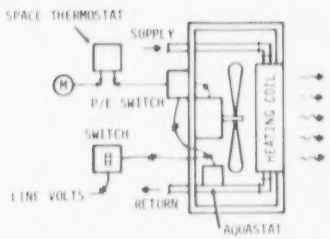
Induction systems generally have units at the outside perimeter of conditioned spaces. Conditioned primary air is supplied to the units, where it passes through nozzles or jets and by induction draws room air through the induction unit coil. Room temperature control is accomplished by modulating water flow through the unit coil.



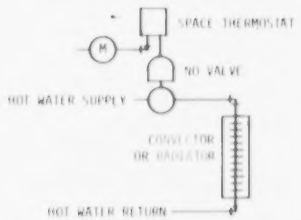
A fan coil unit consists of a cabinet with heating and/or cooling coil, motor and fan and a filter. The unit may be floor or ceiling mounted and uses 100 percent return air to condition a space.



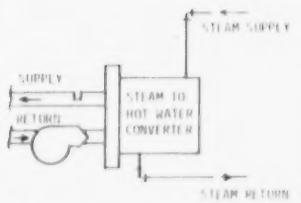
A unit ventilator consists of a cabinet with heating and/or cooling coil, motor and fan, a filter and a return air/outside air mixing section. The unit may be floor or ceiling mounted and uses return and outside air as required by the space.



Unit heaters have a fan and heating coil which may be electric, hot water or steam. They do not have distribution duct work but generally use adjustable air distribution vanes. Unit heaters may be mounted overhead for heating open areas or enclosed in cabinets for heating corridors and vestibules.



Perimeter radiation consists of electric resistance heaters or hot water radiators usually within an enclosure but without a fan. They are generally used around the conditioned perimeter of a building in conjunction with other interior systems to overcome heat losses through walls and windows.



A hot water converter is a heat exchanger that uses steam or hot water to raise the temperature of heating system water. Converters consist of a shell and tubes with the water to be heated circulated through the tubes and the heating steam or hot water circulated in the shell around the tubes.

Courtesy of Honeywell, Commercial Construction Division.

WATER SYSTEM

Domestic hot water may account for two to four percent or more of the total energy consumed in your facility. Chilled water provided in drinking fountains also is a factor in total energy consumption. Aside from the need to conserve water, a careful examination of the domestic water system will indicate opportunities for energy savings.

For more information see:

Energy Conservation Standards, which includes a discussion of domestic hot water, Chapter 8 (page 195).

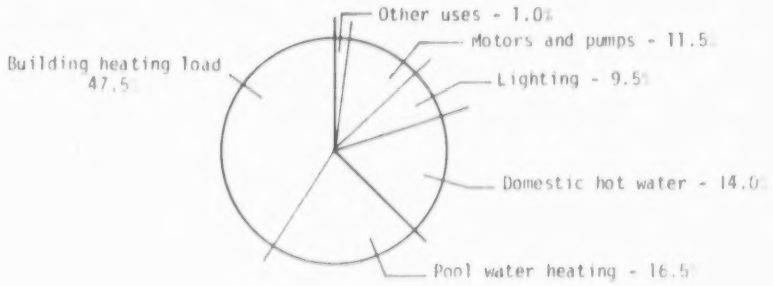
Total Energy Management (TEM), Section Six (page 36).

How to Save Energy and Cut Costs in Existing Buildings, which devotes Sections Five (page 139) and Fourteen (page 393) to hot water conservation.

Put Your House to Work Saving Money for You!, for instructions on how to insulate a hot water tank (page 58).

SWIMMING POOL AND NATATORIUM

A study done for the King County, Washington Park System identified a number of major energy uses related to the operation of an indoor swimming pool. These uses are shown in the following chart.



Efficient, healthful and comfortable pool operation requires that pool water and air temperature and relative humidity within the natatorium be carefully controlled. Many problems, including condensation and corrosion, discomfort, and heating energy wast will arise from improper and wrongly coordinated environmental conditions.

In addition, most pool water and space heating systems are designed to operate within the ranges of conditions in the following table. If these ranges are exceeded, equipment will be overloaded and unable to control the desired conditions. Further, overloaded equipment is inefficient and wastes energy.

Pool and Pool Area Conditions (from ASHRAE 1978 Applications Manual)

Indoor air conditions:	
Pleasure swimming	75°F to 85°F, 50% to 60% relative humidity
Therapeutic pools	85°F to 95°F, 50% to 60% relative humidity
Pool water temperature:	
Pleasure swimming	75°F to 85°F
Competitive swimming	72°F to 75°F
Therapeutic pools	85°F to 95°F
Minimum air requirements (more may be required):	
Pools without spectator facilities	4 to 6 air changes per hour
Pools with spectator facilities	6 to 8 air changes per hour
Therapeutic pools	4 to 6 air changes per hour

but no more than 25 feet per minute (fpm) air movement at a point 8 feet above the pool deck and water.

Lower relative humidities than those recommended -- some sources suggest a lower minimum of 45 percent -- cause chilling of swimmers emerging from the pool by evaporative cooling. Higher relative humidities cause condensation and corrosion problems.

Rules of Thumb

Because of the variety of pool and pool system designs there are few hard and fast rules, other than those listed on the preceding page, about pool operations. However, there are a number of useful rules of thumb which should be followed. Relative humidity should stay within limits and pool water and space heating will be efficient if the air temperature is from 3°F to 5°F higher than the water temperature. This does not apply to therapeutic pools.

A good combination for pools is 75°F pool water and 78°F space air temperature. This combination should control relative humidity with proper air movement and create an environment in which both swimmers and non-swimmers are comfortable, while minimizing energy waste.

Conditions and pool-related energy use should be monitored regularly, as are other pool conditions (pH, cleanliness, etc.). A pool manager may wish to learn to use psychrometric charts as an aid in monitoring and maintaining efficient and comfortable pool conditions.

Increasing Efficiency in Other Components

The importance of applying all the other energy management techniques in this manual is indicated by the energy use percentages in the circle chart on the last page. Obtaining better control over building heat losses, use of domestic hot water (largely showers) and amount and use of lighting can easily provide more energy use reductions than can work with the pool water-air temperature relationship. Typically, work in these areas is also easier to do.

PROFESSIONAL SERVICES FOR ENERGY MANAGEMENT

> One fine day, a French balloonist took off on a trip near the English Channel. A sudden storm blew the craft right across the water. The Frenchman landed in a field in England. As he rolled out of the basket, a man came running up and asked if the balloonist was alright. "Yes," he said, "but where am I?" "In a field," replied the Englishman. "You must be a consultant," said the Frenchman. Rather flattered, the Englishman answered, "Why, yes. How did you know?" "Because," replied the Frenchman, "the information you have given me is accurate, but useless."

The agency team may hesitate to seek out and hire an energy management consultant. This field of consulting is relatively new and of a technical nature; therefore, you lack the benefit of past experience. The following guidelines should facilitate the process of hiring an energy management consultant.

First, the word consultant must be defined in terms of the task for which services are needed. Since the building's mechanical systems consume a large percentage of the total energy, it is wise to look toward the professional engineering field for consulting services. In considering choices, be sure that the consulting firm is staffed with licensed professional engineers in your state, and that the engineers have personal experience in HVAC systems, electrical systems, building materials, and energy efficiency.

A consulting firm of professional engineers offers the advantages of having freedom from special interests, and a knowledge of available materials and equipment life/safety and building codes. Therefore, each individual case can be evaluated independent of the biases of manufacturers, and this evaluation can be based on a good working knowledge of the requirements of the particular situation. Retaining a consultant with this type of background will create an environment in which a successful energy management program can grow.

The problem of how to select an engineering consultant can be difficult. The selection procedure outlined below carefully avoids the problem of competitive bidding, which is illegal for professional engineers in some states, and, in addition, creates an atmosphere that may encourage a firm to quote a minimal fee. This can be disadvantageous since, once the contract is signed, the firm may be tempted to provide only minimal services, in order to realize a larger profit. What is most desirable to the agency is a contract that allows the firm to provide the required services at a fair and reasonable cost. The recommended procedures for selecting a consultant are outlined in six steps:

1. Select three or four firms to interview, based on recommendations from other agencies, associates, or a local professional engineering society.

2. Interview each firm and select the most competent, based on staff experience and a thorough investigation of the history and performance of the firm as determined by contacting former clients.

3. Request a proposal from the selected firm which sets forth the work to be accomplished, a tentative time schedule and the fees.

4. Review the proposal. Then meet with with the consultant to discuss all aspects of the proposal to ensure complete understanding.

5. If, after meeting with the firm, the proposal is found to have areas that are unacceptable, negotiate further with the firm to work out the problems. If negotiations fail, inform the firm of the problems and end negotiations.

6. Select one of the remaining firms and request a new proposal. Once a favorable proposal is negotiated, request a written contract from the firm based on the proposal.

The major points which should be included in the contract are listed below, and it may save time and effort if the points are reviewed with the consulting firm before the written contract is prepared.

The contract should include the following items:

1. Discussion of goals and objectives of the agency.

2. A proposed approach to the energy management problem, including:
   a. An initial building survey to determine the energy savings. The survey should be summarized in a written report, and blank forms showing the typical information to be collected for each building should be included with the contract submittal.
   b. Analysis of suggested energy saving building modifications on a cost/benefit basis to determine which changes result in the most favorable economic conditions.
   c. Engineering responsibility for plans and specifications prepared to implement building modifications, or provision to collaborate with another firm in the preparation of the contract documents to ensure that the intent of the recommendations of the energy study is carried out.
   d. On-site review of the project during construction.
   e. An operating and instruction manual for the building maintenance staff.
   f. A report which shows results actually obtained by monitoring metered utility consumption for at least one year after modifications are complete.
   g. A section on staffing, costs and time schedule.

The contract provides a firm basis on which the energy management project can be executed; therefore, it should be carefully reviewed and understood by the consultant and the energy management team.

Adapted from Robert H. Fuller, Research Coordinator, The Ohio State University & Engineering Consultant: "Acquiring Professional Services for Energy Management," Energy Sourcebook for Educational Facilities, Council of Educational Facility Planners, International, 1977.

MODEL "MAXI-AUDIT" CONSULTANT CONTRACT

The model "total energy audit," or "maxi-audit" contract, given below outlines all items that need to be included in such a contract with a consultant or consulting firm. It can be used as a discussion draft in working with the architectural/engineering firm you choose to retain, or it may serve as the model for your contract. One small warning: It is written in "contract-ese," but don't be discouraged by the sometimes confusing jargon of contract language.

Duties of Consultant

The consultant shall make a comprehensive study of energy use at (agency name) located at (agency address).

This study will include a detailed list of recommended energy conservation measures separated into the following grouping of energy-using functions:

- o space heating/boiler room
- o domestic water heating
- o ventilation (temperature control)
- o airconditioning
- o lighting
- o building envelope
- o miscellaneous (i.e., program or scheduling modifications)

All of the energy used in the agency can be assigned to these functions. Because these functions are interrelated in several ways, there may be some overlapping of recommended conservation suggestions.

Description of "Maxi-Audit"

In the absence of records from extensive submetering systems, it is necessary to conduct an inventory of energy-using apparatus to calculate the design loads under existing operating conditions to project the normal monthly use of energy in a representative weather year, and to divide the recorded monthly purchases of electricity, gas, oil, coal, steam, etc. among the functional uses in accord with prudent judgment based on the inventory and calculations.

A careful survey of the building facilities must be undertaken to identify the energy-using apparatus, to measure or estimate the rate of energy use at each device and to determine the circumstances that control the frequency and duration of operation and the part-load response.

It is helpful to start with a set of "as built" construction drawings, accurate test and balance data, definitive temperature control system diagrams and a descriptive sequence of operations. In any event, it is necessary to determine: the physical dimensions of the building; construction materials used; compass orientation; shading effect of adjacent buildings or permanent plantings;

applicable ventilation requirements; complete data on lighting systems, people occupancy, appliances and equipment used in the facility. From these data the design heating, ventilating and cooling loads can be calculated for the extreme outdoor weather conditions, winter and summer, and the desired indoor temperatures and humidity. Detailed instructions on a standard method of performing this calculation are included in ASHRAE Handbook of Fundamentals.

The results of design load calculations can be used to estimate the annual heating and cooling loads by manual or computerized procedures that simulate operational conditions, the influence of hours of occupancy and a model year weather occurence including available sunshine and the annual 8,760 hourly occurences of dry bulb and wet bulb conditions.

The inventory of energy-using apparatus should include the equipment used for functions other than adding and removing heat. Each such item or grouping of items should be assigned a maximum rate of energy consumption and a program to start, stop and part-load performance for each month. These data are then combined to produce the monthly and annual Btu and kwh of energy used for operation of these air handling, fluid handling, hot water heating, appliance, process, transportation, interior and exterior lighting functions.

The total monthly Btu of heat energy required for all heating functions should then be divided by appropriate monthly fuel conversion efficiency factors to determine net heating fuel energy required per month in a normal year.

The total monthly heat gains and hours of refrigeration plant operation for each month must be used to produce the monthly kwh of electricity (and Btu of heat, where applicable) to absorb the building heat gains and transfer them to the environment.

After the estimated energy use has been calculated for applicable energy use functions, the monthly records of electricity, gas, oil, coal, steam, etc., for two or more years should be analyzed. Heating fuel should be converted to Btu of heat content purchased per month. The demand and energy consumption records on the electric bills may be used directly. These records should be adjusted to reflect any known deviations from the "normal" year usage, and weather data used in the calculated energy estimate and an adjusted month-by-month tabulation of purchased fuel Btu and electric kw and kwh should be developed.

The adjusted purchased energy tabulation should then be compared with the calculated energy budget estimate to identify substantive differences. Where deviations are significant, the budget estimate assumptions should be reviewed. If the budgeted values are deemed realistic, then the source of excessive energy consumption should be identified and an evaluation should be made of the cost/benefit relationship to improve the condition. Analysis of the quantity of energy used for each function will reveal the areas in which remedial effort may produce significant results. Adjustment of performance levels of the various building services or other changes that reduce design loads and modify operating characteristics may be analyzed for impact on costs and energy consumption. Simulation of the effects of proposed modifications can be individually considered to optimize effort and expense.

Suggested "Maxi-Audit" Procedure

Actual audits may deviate from this procedure when the following suggested criteria are not appropriate.

A. Calculate design heating and cooling loads for the building as constructed and used.
   1. Compare construction drawings to existing conditions to identify any deviations, such as: window shading devices, infiltration through windows and doors, quality of thermal insulation, lighting devices installed and used, appliances and process equipment in use, substantial reassignment of space functions, etc.
   2. Establish operating techniques that are currently employed: temperature and humidity conditions, ventilation rate, operating capacity and power requirements of fans, pumps, compressors, etc.
   3. Based on drawings and observations, calculate maximum heating load at winter design conditions and summarize subtotals:
      a. Btu/hour conduction loss with no solar or internal heat gains.
      b. Outdoor air infiltrated, cubic feet per minute (cfm) when building ventilation equipment is off.
      c. Outdoor air introduced and exhausted, cfm when ventilation equipment is on.
   4. Based on drawings and observations, calculate maximum cooling load at summer design conditions and summarize subtotals:
      a. Btu/hour conduction gain at simultaneous peak time.
      b. Btu/hour solar heat gain at peak condition for each of cardinal compass points and for horizontal surfaces.
      c. Outdoor air introduced and exhausted, cfm when ventilation equipment is on in the cooling mode.
      d. Btu/hour of heat gained in the building from lighting devices.
      e. Btu/hour of heat gained in the building from appliances and processes.
      f. Btu/hour of heat gained from building occupants.
      g. Btu/hour of heat gained from temperature control system and HVAC components.
   5. Based on drawings and observations, calculate normal electrical energy used, kw per hour, occupied and unoccupied modes, by heating and airconditioning distribution apparatus.
   6. Based on drawings and observations, calculate normal electrical energy used, kw, or heat energy used, Btu/hour, occupied and unoccupied modes, by processes and appliances that are not included in item 4 above. Do not include energy requirements of fuel conversion process or refrigerati for airconditioning in this summary.
      a. Building transportation, elevators, escalators, conveyors, etc.
      b. Domestic water pumps, sewage and sump pumps, drinking water coolers.
      c. Food refrigeration and cooking.
      d. Domestic water heating and laundry operations.
      e. Process air compressors.
      f. Boiler accessories, feed water systems, fuel pumps.
      g. Office and production machinery.
      h. Miscellaneous.

B. Calculate monthly energy load and annual totals for the building heating, ventilation and cooling requirements during normal use and weather (energy output).

1. Determine occupancy levels and durations for major building areas.
2. Establish performance requirements of automatic temperature control system and components, and identify impact of control sequence on refrigeration and heating loads.
3. Determine programs of start/stop apparatus, heat/cool changeover criteria, winter unoccupied mode set back temperature, use of outdoor air for nonrefrigerated cooling, exhaust air equipment operating schedule.
4. Establish a model weather year, including local normal outdoor temperature and humidity experience for each month and characteristic local interference with available sunlight because of cloud cover or other atmospheric conditions. Weather experience should be indexed to the usual occupancy conditions of the facility so that weather incidents that occur when the building is unoccupied are separated from the weather that is coincident with building occupancy.
5. Based on the data assembled, calculate normal monthly totals of energy required to serve the heating, cooling and ventilation loads and tabulate in sufficient detail to allow analysis. The calculation must include a simultaneous determination of heat losses and gains for each weather incidence and with appropriate considerations of applicability of the gains to the losses. In addition, the calculations must account for the automatic and manual control of the heating and cooling apparatus so as to reflect the response of the energy-using equipment to changing requirements of weather and occupancy.

C. Calculate monthly consumption of energy and annual totals required by the building systems (energy input).
   1. Tabulate fuel input (or electrical energy) to serve heating, domestic hot water and process loads, including suitable provisions for conversion efficiency at varying loads.
   2. Tabulate electric energy input for refrigeration system components required to serve the airconditioning loads.
   3. Tabulate fuel input to serve heat actuated refrigeration equipment required to serve the airconditioning load.
   4. Tabulate electric energy input separately for interior illumination, air handling equipment, fluid handling equipment, boiler and heating accessories and other electrical loads.

D. Compare and adjust calculated energy input totals with records of fuel and electricity purchase records for a two year span.
   1. Adjust records of monthly fuel and utility bills to reflect calendar months in lieu of billing periods, and aberrations in experience because of deviations from normal occupancy and weather.
   2. Compare calculated energy input with adjusted records of fuel and utility purchases. Where calculated energy is greater than adjusted purchases, review the calculation input information and adjust the calculations to reflect actual usage. This revised tabulation is the energy budget. Where purchased energy exceeds the budget, there is opportunity for increased efficiency.

E. Recommend energy conservation measures (separate into standard groupings).

   1. Analyze the maximum heating and cooling loads to determine opportunities for load reduction by modification of the building envelope thermal

effectiveness and for changes in ventilation rate and boiler modifications. The probable results of such changes can be measured or estimated by calculating the annual energy use and determining the effect on energy purchases.

2. Analyze the energy used by air handling and fluid handling equipment. If substantial changes are made in heating and cooling loads, it may be possible to make beneficial revisions to the apparatus and use of these subsystem components to further reduce energy consumption.
3. Analyze the building automation systems and determine the effects of changes to start/stop programming, night setback, temperature control sequences and set points. Changes in occupancy schedules should be considered in assessing possible reductions of hours of equipment operation.
4. Review budgeted allowances for processes and appliances and make detailed analysis where the quantities justify the effort.
5. Review budget allowances for lighting energy and analyze apparatus, performance levels and operational techniques to reduce energy consumption. If substantial changes are made in reducing lighting energy use, the heating and cooling loads will be affected and there may be beneficial revisions in other energy uses.
6. Analyze budget allowances for energy conversion apparatus, i.e. refrigeration system, fuel conversion equipment, etc., and calculate annual efficiencies. Considering probable changes in building loads, operation schedules, temperature control system, etc., estimate possible impacts on energy conversion efficiencies.
7. Recalculate the annual energy uses for the project as it would be modified by energy conservation measures selected as most probable. This evaluation will provide a reasonable basis for predicting effects of proposed changes on energy purchases.
8. Identify the expected reduction in energy use for each proposed change in the program so that the performance can be measured and the responsibility for continued surveillance can be allocated.
9. Develop suitable monitoring procedures to record the performance of modified equipment or procedures. Recommend instrumentation such as:
   a. Elapsed time meters to record hours of operation of prime movers.
   b. Electric watt-hour meters to record usage of electric energy for specific operations or departments.
   c. Fuel meters to record consumption of fuel for specific operational purposes.
   d. Btu meters, steam flow meters or condensate meters to identify heat input or output of processes or building environmental apparatus.
   e. Recording thermostats to verify performance of critical automatic temperature controls.
   f. Recording ammeters to monitor relative load changes in electric prime movers and power distribution feeders.
10. Develop reporting procedures and summaries to monitor the operating and maintenance personnel execution of energy conservation program elements. Daily, weekly and monthly logs of equipment use, meter readings and performance evaluations should be summarized and reported to operating personnel. Continued reference to performance goals and actual achievement is necessary to sustain interest and reward successful effort and skill at the level at which operating decisions are actually made.

11. Prepare comparative statements of energy use semi-annually to show the actual purchases of electricity and fuel compared to the energy budget and the adjusted record of energy purchased in the past. Graphic presentations may provide a continuing synopsis of the effects of energy conservation and management programs.

Adapted from "Model Maxi-Audit Contract for Consultant Services," Energy Sourcebook for Educational Facilities, Council of Educational Facility Planners, International, 1977.

LIFE-CYCLE COSTING

Life-cycle costing is a series of uncomplicated decision-making techniques for determining the total cost of a product over its entire life. It gives energy managers the tools with which to judge the long-term financial consequences of purchasing certain equipment or engaging in particular retrofit operations. The idea of life-cycle costing is very important to good energy management because a decision to purchase equipment based solely on a comparison of first cost (the initial cost of the product) may be deceptive. Very often a product whose first cost is considerably more than another may actually prove less expensive over the life of the product, or on a life-cycle basis. We have all experienced this when purchasing household appliances. For example, the new "energy saving appliances" often cost more than similar devices that do not have energy saving features. But, the energy saving appliance is likely to be a better buy because it will cost less to operate.

In order to appreciate the importance of life-cycle costing in decision-making, consider a technique which does not take life-cycle costing into account -- simple payback period analysis. A simple payback period is the amount of time necessary for the money saved by using a piece of equipment to equal the cost of the equipment. In other words:

$$\frac{\text{Initial cost}}{\text{Annual savings}} = \text{Simple payback}$$

For example, if it costs $1,500 to install an energy saving device that will save $750 per year, the payback period will be two years.

$$\frac{\$1,500}{750} = 2 \text{ years}$$

The use of simple payback period analysis is limited since it does not consider the effects of inflation or the time value of money. Suppose two types of energy conserving devices cost the same amount. Device A has a payback period of two years and a usable life of ten years, while Device B has a payback period of three years, but a usable life of 15 years. Simple payback period analysis will not reflect which one is a better buy. It will only give a general idea of a device's cost-effectiveness. Life-cycle costing, on the other hand, is more accurate because it lets you determine which device is the most cost-effective, by considering all the costs of a device over its life.

There are various ways of determining life-cycle costs. One method is "discounted cash flow," or "discounting money to the present value." This method recognizes that one dollar today is worth more than one dollar received in the future, and that borrowing money always involves a compound interest charge. Any bank depositor is familiar with how compound interest works. If a depositor puts $100 dollars in the bank today, that $100 amount will increase every year as interest is compounded. In one year, that $100 at six percent interest will be $106; in two years it will grow to $112.36.

Discounting to the present value is actually a compound interest problem in reverse. We know how much money will be saved by purchasing a certain energy saving device. Knowing the interest rate, we can figure out the present value of the anticipated savings by using a table (see table at end of chapter).

The rule to remember when discounting to the present value is: if the total present value of the savings is greater than the initial cost (first cost) of the capital investment, the investment is sound.

For example, an energy management team decides to buy a $40,000 energy saving device which will reduce energy costs $10,000 a year. To determine the cost-effectiveness of this potential investment, a team member computes the present value of the estimated savings, assuming a six percent discount factor, for the next five years. (This data also incorporates an annual rate of energy price increase.)

Computing the Present Value of the Estimated Savings at Six Percent

Year	Savings in that year		Six Percent Discount Factor		Present Value
1	$10,000	X	.9434	=	$9,430
2	$10,000	X	.8900	=	$8,900
3	$10,000	X	.8396	=	$8,396
4	$10,000	X	.7921	=	$7,921
5	$10,000	X	.7473	=	$7,473

Total Present Value of Annual Savings: $42,124

- $42,000

$ 2,124

If the total present value of the savings exceeds the amount required for the initial investment, that investment should be recommended.

In this case, the energy management team relates the techique of discounting to the present value to figuring out whether to invest in certain energy conservation equipment.

In a second example, an energy management team is considering investing in one of two possible energy saving systems. Each has an economic life of 20 years, and will incur the following costs:

	System A	System B
Initial capital cost	$50,000	$56,000
Annual cost: Energy	3,200	2,400
O&M	2,000	1,300
Total Annual Cost	5,200	3,700

The initial cost of System B is $6,000 greater than System A, but System A will require $800 more per year for energy and $700 more annually for operations and maintenance.

Assume a 10 percent annual interest rate on the additional $6,000 for an investment in System B over System A, and annual escalation rates of eight percent for energy costs and four percent for operations and maintenance costs. Using the table below, team members see that for System B, the present value factor for energy savings is 16.59, and for operations and maintenance savings the factor is 11.69.

Present Value Factors (at 10 percent discount rate)

Annual Rate of Energy Price Increase	(Economic Life) 5	10	15	20	25
0%	3.79	6.14	7.61	8.51	9.08
2%	4.01	6.76	8.64	9.93	10.82
4%	4.24	7.44	9.86	11.69	13.07
6%	4.48	8.20	11.30	13.87	16.00
8%	4.73	9.05	12.99	16.59	19.87
10%	5.00	10.00	15.00	20.00	25.00
12%	5.28	11.06	17.38	24.30	31.87

The present value of the future savings in energy costs and operations and maintenance is computed as follows:

Present value of future energy savings = $800* X 16.59 = $13,272

Present value of future O&M savings = $700** X 11.69 = $8,183

*Difference in energy costs (A - B) = $3,200 - 2,400 = $800
**Difference in O&M costs (A - B) = $2,000 - 1,300 = $700

The present value of the total future savings in both energy costs and operations and maintenance costs is: $13,272 + $8,183 = $21,455. Compared with the present value of the current $6,000 savings in initial costs, System B will actually be much less expensive than System A.

Another method of determining life-cycle costs is to calculate the benefit/cost ratio, or the relationship between the benefit of a piece of equipment and the cost of achieving that benefit. More simply,

$$\text{benefit/cost ratio} = \frac{\text{annual savings}}{\text{annual costs}}$$

A benefit/cost ratio of 1/1, or 1.00, would mean that for every dollar spent annually (cost), an equal amount, one dollar, would be earned back in annual savings (benefit). Therefore, a benefit/cost ratio of 1.00 or more indicates a sound investment. The goal of benefit/cost analysis is to obtain the most in annual savings for every dollar spent in annual costs. Annual savings and annual costs for each investment alternative being considered must be determined to establish benefit/cost ratios.

To use benefit/cost analysis, it is necessary to understand the concept of annual debt service, or the amount of money paid each year in order to repay a loan over X number of years. Annual debt service is based on the estimated economic life of a piece of equipment. It is determined by multiplying the principle by the capital recovery factor for a specific rate of interest and payback period (see table below).

Capital Recovery Factor

Year	(Interest rate) 6%	7%	8%	10%	12%
5	.2374	.24389	.25046	.26380	.27741
10	.1359	.14238	.14903	.16275	.17698
15	.1030	.10979	.11683	.13147	.14682
20	.0872	.09439	.10185	.11746	.13388
25	.0782	.08581	.09364	.11017	.12750
30	.0726	.08059	.08883	.10608	.12414
40	.0665	.07501	.03386	.10226	.12130

The table shows that the capital recovery factor for a 20-year loan at an annual interest rate of 10 percent is .11746. Applying this amount to a capital investment of $100,000 results in an annual debt service of: $100,000 X .11746 = $11,746. That is, a loan of $100,000 at 10 percent annual interest will require payment of $11,746 for 20 years, or $11,746 X 20 = $234,920.

As a member of the energy management team, consider the following two possible investments:

	System A	System B
Total first costs	$18,000	$20,000
Annual O&M and energy costs	1,600	1,000

The first cost of System B is $2,000 greater than System A. However, System A will cost $600 more annually to run. In order to obtain the $600 in annual savings from System B, an initial investment of $2,000 must be made.

To determine the benefit/cost ratio, the current $2,000 additional first cost must be defined in the same units (annual cost) as the $600 benefit, to make the ratio meaningful. Convert the $2,000 first cost to annual cost by using a capital recovery factor from the table above. Assuming a 20-year economic life for both systems and a 10 percent annual interest rate, the capital recovery factor is .11746. The annual cost of investing in System B is: $2,000 X .11746 = $234.92.

Now that both the benefit and the cost are defined annually it is possible to calculate the benefit/cost ratio.

$$\frac{\text{annual savings}}{\text{annual cost}} = \frac{\$600}{234.92} = 2.55$$

The benefit/cost ratio of 2.55 means that for every dollar spent annually to repay the additional $2,000 first cost of System B, an annual savings of $2.55 in O&M and energy costs is realized.

Another way of determining the benefit/cost of a project is to figure out the internal rate of return, or the interest rate that makes the present value of the cash proceeds (benefit) from an investment equal to the present value of the cost of the project (cost).

This interest rate can usually be figured out by trial and error. It is the maximum rate of interest that can be paid if all the capital used to finance an investment was borrowed, and the loan was repaid with funds generated by the investment. To find it, you need to determine the interest rate that makes the sum of the present values of the anticipated cash flow from an investment equal to zero (or the cost of the project). For example, the anticipated cash flows for a particular project are:

Initial investment

Year 1 = $12,337
Year 2 = $10,000
Year 3 = $ 5,000

An interest rate of 16 percent (determined by trial and error) would be used to obtain a net present value of zero. Thus:

Cash flow	Present value factor (from Table I)	Present value
- 12,337 *	1.0000	- 12,337
10,000	0.8621	8,621
5,000	0.7432	3,716
		0

(* indicates initial investment)

This indicates that 16 percent is the yield of the investment. In deciding whether to pursue this project, an energy manager must determine if another investment for the same time period would offer a higher yield, and thus be more desirable.

The concepts of simple payback, discounting to the present value, benefit/cost ratio and internal rate of return are important to effective energy management. Although these are not complicated techniques, if you have never worked with them before you will need to read this section more than once to understand them fully. INVEST THE TIME! A good energy manager should use life-cycle costing in judging the value of different enery saving investments. Using all of these methods in decision-making will be like putting together the pieces of a jigsaw puzzle. Each piece alone is only a part. Putting all the pieces together will create a complete and understandable picture.

TABLE I

PRESENT VALUE OF $1 DUE IN n PERIODS

n	2%	3%	4%	5%	6%	8%	10%	12%	16%	20%
1	0.9804	0.9709	0.9615	0.9524	0.9434	0.9259	0.9091	0.8929	0.8621	0.8333
2	0.9612	0.9426	0.9246	0.9070	0.8900	0.8573	0.8264	0.7972	0.7432	0.6944
3	0.9423	0.9151	0.8890	0.8638	0.8396	0.7938	0.7513	0.7118	0.6407	0.5787
4	0.9238	0.8885	0.8548	0.8227	0.7921	0.7350	0.6830	0.6355	0.5523	0.4823
5	0.9057	0.8626	0.8219	0.7835	0.7473	0.6806	0.6209	0.5674	0.4761	0.4019
6	0.8880	0.8375	0.7903	0.7462	0.7050	0.6302	0.5645	0.5066	0.4104	0.3349
7	0.8706	0.8131	0.7599	0.7107	0.6651	0.5835	0.5132	0.4523	0.3538	0.2791
8	0.8535	0.7894	0.7307	0.6768	0.6274	0.5403	0.4665	0.4039	0.3050	0.2326
9	0.8368	0.7664	0.7026	0.6446	0.5919	0.5002	0.4241	0.3606	0.2630	0.1938
10	0.8203	0.7441	0.6756	0.6139	0.5584	0.4632	0.3855	0.3220	0.2267	0.1615
11	0.8043	0.7224	0.6496	0.5847	0.5268	0.4289	0.3505	0.2875	0.1954	0.1346
12	0.7885	0.7014	0.6246	0.5568	0.4970	0.3971	0.3186	0.2567	0.1685	0.1122
13	0.7730	0.6810	0.6006	0.5303	0.4688	0.3677	0.2897	0.2292	0.1452	0.0935
14	0.7579	0.6611	0.5775	0.5051	0.4423	0.3405	0.2633	0.2046	0.1252	0.0779
15	0.7430	0.6419	0.5553	0.4810	0.4173	0.3152	0.2394	0.1827	0.1079	0.0649
16	0.7284	0.6232	0.5339	0.4581	0.3936	0.2919	0.2176	0.1631	0.0930	0.0541
17	0.7142	0.6050	0.5134	0.4363	0.3714	0.2703	0.1978	0.1456	0.0802	0.0451
18	0.7002	0.5874	0.4936	0.4155	0.3503	0.2502	0.1799	0.1300	0.0691	0.0376
19	0.6864	0.5703	0.4746	0.3957	0.3305	0.2317	0.1635	0.1161	0.0596	0.0313
20	0.6730	0.5537	0.4564	0.3769	0.3118	0.2145	0.1486	0.1037	0.0514	0.0261
25	0.6095	0.4776	0.3751	0.2953	0.2330	0.1460	0.0923	0.0588	0.0245	0.0105
30	0.5521	0.4120	0.3083	0.2314	0.1741	0.0994	0.0573	0.0334	0.0116	0.0042
40	0.4529	0.3066	0.2083	0.1420	0.0972	0.0460	0.0221	0.0107	0.0026	0.0007
50	0.3715	0.2281	0.1407	0.0872	0.0543	0.0213	0.0085	0.0035	0.0006	0.0001

103

For more information see:

General Services Administration, Federal Supply Service, Life-Cycle Costing Workbook, Washington, D.C., 1977.

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Wagner, Report of Literature Search and State-of-the-Art Life-Cycle Costing, University of South Dakota, 1978.

TEM, Chapter 7, page 55.

BASIC DATA AND REFERENCE TABLES

Water Volume

1 gallon	= 8.33 lbs.
1 gallon	= 0.134 cubic feet
1 cubic foot	= 7.48 gallons
1 cubic foot	= 62.3 lbs.

Water Pressure

1 lb./sq. inch	= 2.31 feet of water
1 foot column of water	= 0.4331 lbs./sq. inch

Natural Gas

1 therm	= 100,000 Btu
1 MCF	= 1000 cubic feet
1 MCF	= 10.00 therms
1 cubic foot	= 1000 Btu

Liquid Fuels

Propane	= 91,500 Btu/gallon
# 2 fuel oil	= 140,000 Btu/gallon
# 4 fuel oil	= 145,000 Btu/gallon
# 6 fuel oil	= 154,000 Btu/gallon

Power and Heat

WATT	= 3.41 Btu
KW	= 1000 Watts
KWH	= kilowatt-hour 3,412 Btu/hr.
1 ton refrigeration	= 12,000 Btu/hr.
1 lb. Steam	= 1000 Btu

Note: Values given for fuels are gross average values which have been rounded off. They may vary -- check supplier for exact values. Also, see Table II in this section for more precise figures.

TABLE I

CLIMATE RELATED FACTORS

LOCATION	HEATING SEASON TEMPERATURE °F DESIGN	HEATING SEASON TEMPERATURE °F AVERAGE	HEATING SEASON LENGTH WEEKS	HEATING SEASON DEGREE DAYS	COOLING SEASON TEMPERATURE °F DESIGN	COOLING SEASON TEMPERATURE °F AVERAGE	COOLING SEASON LENGTH WEEKS	COOLING SEASON DEGREE DAYS
Alabama								
Birmingham	18.0	41.9	16.6	2,780		80.6	32.9	
Huntsville	19.0	40.3	18.8			80.5	30.9	
Arizona								
Phoenix	31.0	46.4	11.4	1,492		86.0	41.3	2,691
Arkansas								
Little Rock	15.0	41.7	18.1	2,982		81.6	31.3	
California								
Fresno	27.0			2,532				1,375
Los Angeles	35.0	50.2	8.9	1,451		72.0	32.6	1,026
Sacramento	29.0	46.1	19.4	2,600		79.9	28.4	1,021
San Diego	43.0	50.5	7.0	1,574		70.9	29.8	
San Francisco	36.0	48.2	18.4	3,069		71.1	22.2	210
Santa Barbara	33.9	49.6	23.9			69.7	12.2	
Colorado								
Denver	- 3.0	35.2	29.4	5,673		77.9	22.6	615
Delaware								
Wilmington	12.0	38.2	26.0			77.5	23.7	
Florida								
Jacksonville	29.0	45.6	8.6	1,113		80.4	41.6	3,245
Miami	44.0	49.3	1.6	173		80.4	50.1	4,603
Pensacola	29.0	44.7	10.4	1,435		79.4	38.4	
Tampa	35.0	47.0	4.0	674		78.5	46.0	3,669
Georgia								
Atlanta	19.0	41.1	19.8	2,811		78.7	30.0	2,152
Augusta	20.0	42.6	16.0	2,138		80.7	35.1	
Macon	24.0	43.3	14.5	2,049		80.3	34.8	

LOCATION	HEATING SEASON TEMPERATURE °F DESIGN	AVERAGE	LENGTH WEEKS	DEGREE DAYS	COOLING SEASON TEMPERATURE °F DESIGN	AVERAGE	LENGTH WEEKS	DEGREE DAYS
Illinois								
Chicago	-4.0	34.2	30.0	6,310		77.0	20.9	1,292
Peoria	-3.0	34.0	26.0	6,087		78.0	24.0	
Indiana								
South Bend	-2.0	34.2	29.1			77.1	21.4	
Iowa								
Des Moines	-8.0	32.1	28.0	6,274		78.4	21.9	
Sioux City	-9.0	31.2	28.9	7,012		79.0	22.2	
Kansas								
Kansas City	4.0	36.5	23.6			80.5	25.7	
Wichita	3.0	37.9	22.6	4,571		81.2	27.0	
Kentucky								
Louisville	6.0	38.4	23.5	4,279		79.9	26.6	
Louisiana								
New Orleans	31.0	46.4	9.4	1,175		79.8	39.6	3,365
Shreveport	21.0	42.6	15.2	2,117		81.8	35.2	2,900
Maine								
Portland	-6.0	34.5	33.7	7,681		74.4	15.5	
Massachusetts								
Boston	6.0	35.1	31.1	5,791		76.0	19.8	997
Springfield	-4.0	34.6	30.5			76.3	20.1	
Michigan								
Detroit	4.0	33.8	30.5	6,469		75.8	19.2	
Lansing	-7.0	34.0	30.4	6,982		76.0	19.5	
Minnesota								
Duluth	-19.0	28.0	37.0	9,574		73.5	12.7	
Minneapolis	-14.0	29.3	31.0	7,853		76.8	18.3	1,012

LOCATION	HEATING SEASON TEMPERATURE °F DESIGN	HEATING SEASON TEMPERATURE °F AVERAGE	HEATING SEASON LENGTH WEEKS	HEATING SEASON DEGREE DAYS	COOLING SEASON TEMPERATURE °F DESIGN	COOLING SEASON TEMPERATURE °F AVERAGE	COOLING SEASON LENGTH WEEKS	COOLING SEASON DEGREE DAYS
Mississippi								
Jackson	23.0	43.0	14.8			81.1	35.3	2,656
Missouri								
Kansas City	4.0	36.5	23.6	4,888		80.5	25.7	1,946
Nebraska								
Omaha	-4.0	32.1	27.2	6,160		78.5	23.0	
Nevada								
Las Vegas	23.0	43.7	15.6			86.8	35.4	1,771
Reno	7.0	35.0	33.0	6,035		79.0	21.0	282
New Hampshire								
Manchester	-5.0	32.0	32.0			75.0	19.0	
New Jersey								
Trenton	3.0	37.5	26.9	5,068		77.1	22.9	
New Mexico								
Albuquerque	14.0	39.7	23.9	4,389		80.4	27.3	1,038
New York								
Buffalo	3.0	34.5	31.1	6,838		75.0	18.8	
New York City	10.0	38.0	27.5	4,965		76.0	20.0	1,234
North Carolina								
Raleigh	19.0	41.0	20.0	3,075		79.0	30.0	1,927
Ohio								
Cincinnati	4.0	36.8	25.1	4,532		78.2	24.4	
Cleveland	2.0	34.0	29.4	5,717		76.5	21.0	
Columbus	-1.0	37.8	25.5	5,277		77.6	23.8	1,324
Dayton	1.0	36.2	25.4	5,597		78.4	24.3	
Oklahoma								
Tulsa	12.0	39.0	20.2			81.7	29.7	

LOCATION	HEATING SEASON TEMPERATURE °F DESIGN	HEATING SEASON TEMPERATURE °F AVERAGE	HEATING SEASON LENGTH WEEKS	HEATING SEASON DEGREE DAYS	COOLING SEASON TEMPERATURE °F DESIGN	COOLING SEASON TEMPERATURE °F AVERAGE	COOLING SEASON LENGTH WEEKS	COOLING SEASON DEGREE DAYS
Oregon								
Portland	22.0	44.0	30.8	4,143		75.5	15.8	
Pennsylvania								
Philadelphia	12.0	38.2	26.0	4,523		77.5	23.7	
Pittsburgh	4.0	35.1	28.2	5,048		76.0	21.9	
Williamsport	3.0	36.4	28.9			77.2	21.0	
South Carolilna								
Charleston	24.0	43.3	14.2	1,769		78.7	36.0	2,578
Columbia	23.0	43.2	16.0	2,284		79.7	33.4	
South Dakota								
Sioux Falls	-15.0	29.2	30.4			78.0	20.5	
Tennessee								
Knoxville	10.0	39.5	21.5	3,590		80.0	29.0	1,947
Memphis	17.0	40.5	18.9	3,006		81.1	30.4	2,393
Nashville	12.0	39.3	23.3	3,513		79.7	28.4	2,093
Texas								
Dallas	19.0	42.5	15.1	2,272		82.8	34.6	2,814
Houston	29.0	47.0	6.0	1,276		80.3	42.0	3,383
Utah								
Salt Lake City	2.0	36.5	30.2	5,463		79.0	19.9	764
Vermont								
Burlington	-12.0	31.3	33.1	7,865		74.8	16.7	
Virginia								
Richmond	15.0	40.9	20.9	3,720		77.8	26.8	
Roanoke	15.0	39.8	23.4			78.9	26.3	

LOCATION	HEATING SEASON TEMPERATURE °F DESIGN	AVERAGE	LENGTH WEEKS	DEGREE DAYS	COOLING SEASON TEMPERATURE °F DESIGN	AVERAGE	LENGTH WEEKS	DEGREE DAYS
Washington								
Seattle	24.0	43.7	37.3	4,438		70.9	9.4	197
Spokane	0.0	36.6	34.8	6,852		76.1	15.6	
West Virginia								
Charleston	9.0	38.4	23.7			78.4	26.1	
Wisconsin								
Green Bay	-12.0	31.1	33.0	8,259		75.2	17.5	
Milwaukee	-6.0	33.0	30.0	6,944		77.0	20.9	

SOURCES:

American Gas Association. Gas Comfort Heating and Cooling and Fuel Comparisons. New York: Industrial Press, Inc., 1968, pp. 12/98-12/101.

Departments of the Air Force, the Army and the Navy. Engineering Weather Data. Washington: U.S. Government Printing Office, 15 June 1967, pp. 1-69.

Honeywell, Inc. Energy Conservation with Comfort, 2nd Edition. Honeywell, Inc., 1979, pp. 107-111.

Weather Trends, Inc. Temperature. Volume 1 of the Climatological Atlas of Continental United States. New York: Weather Trends, 1964, pp. 49-53.

TABLE II

ENERGY CONTENT OF FUELS

FUEL	UNITS	UNIT GROSS ENERGY CONTENT (Btu)	EFFICIENCY OF USE	NET USABLE ENERGY CONTENT (Btu)
Natural gas	cf	1,031	76%	785
	therm	100,000		76,000
	ccf	103,100		78,500
	mcf	1,031,000		785,000
Propane	cf	2,500	76%	1,900
lpg	gallon	95,475		72,600
#2 fuel oil (distillate)	gallon	138,690	80%	111,000
#6 fuel oil (residual)	gallon	149,690	80%	120,000
Coal - soft	short ton	25,400,000	80%	20,300,000
Coal - hard	short ton	28,000,000	80%	22,400,000
Steam	mlbs	1,000,000	100%	1,000,000
Electricity (heating)	kwh	3,413	100%	3,413

NOTE: Natural gas and coal figures are averages, local actual values may be used if known. Apply efficiency of use factor to obtain local net.

NOTE: Use net usable energy content values in worksheet calculations.

SOURCE: Public Schools Energy Conservation Service.

TABLE III

AIR CONDITIONING DATA

Building Type	Square Feet/Ton
Hospitals	270
Schools and Colleges	260
Public office buildings	340
Nursing homes	275
Hotels (residential portions)	275

SOURCE: 1979 Oregon Department of Energy Audit Training Manual, p. 7.

TABLE IV

APPROXIMATE POWER INPUTS

System	kw/ton
Window units	1.78
Through-wall units	1.94
Dwelling unit, central air-cooled	1.63
Central Chillers	
Air-cooled (3 to 25 tons)	1.40
Air-cooled (25 to 100 tons)	1.39
Water-cooled (25 to 100 tons)	1.11
Water-cooled (over 100 tons)	0.99

SOURCE: Ibid., p. 7.

TABLE V

NORMAL EQUIVALENT FULL-LOAD OPERATING HOURS

FOR COOLING SEASON

Albuquerque, NM	1,500	Indianapolis, IN	1,100
Atlantic City, NJ	650	Little Rock, AR	1,900
Birmingham, AL	1,700	Minneapolis, MN	600
Boston, MA	800	New Orleans, LA	2,100
Burlington, VT	400	New York, NY	750
Charlotte, NC	900	Newark, NJ	650
Chicago, IL	750	Oklahoma City, OK	1,500
Cleveland, OH	600	Pittsburgh, PA	1,050
Cincinnati OH	1,250	Rapid City, SD	900
Columbia, SC	1,300	St. Joseph, MO	1,300
Corpus Christi, TX	2,250	St. Petersburg, FL	2,100
Dallas, TX	1,400	San Diego, CA	1,250
Denver, CO	600	Savannah, GA	1,300
Des Moines, IA	800	Seattle, WA	800
Detroit, MI	850	Syracuse, NY	600
Duluth, MN	400	Trenton, NJ	900
El Paso, TX	1,200	Tulsa, OK	1,850
Honolulu, HI	2,500	Washington, DC	950

SOURCE: Ibid., p. 8.

TABLE VI

LUMEN OUTPUT RATIO

This table gives approximate ratios of lumens per watt outputs.

	Incandescent to	Fluorescent to
Fluorescent	3.38	
Metal-halide	3.95	1.17
HID	4.81	1.42
Low pressure sodium (lps)	7.82	2.32

TABLE VII

RECOMMENDED LIGHTING LEVELS IN WATTS PER SQUARE FOOT

This table gives reasonable estimates of the wattage per square foot required to provide recommended lighting levels with efficient lighting systems. The fact that an existing lighting system has the equivalent watts per square foot does not mean that the desired lighting level is achieved. Actual lighting levels should and must be measured with an appropriate light meter.

		Watts per square foot	
Space Type	Footcandles	Fluorescent	lps
Offices	70	3.25	N/A
Meeting rooms	50	2.80	N/A
Shop areas	100	4.60	N/A
Gymnasiums	30	1.19	0.75
Auditoriums	15	0.60	0.40
Locker rooms	30	1.00	N/A
Corridors, lobbies	20-	1.00	N/A

N/A = Use not advised in this space because of light characteristics.

SOURCE: Public Schools Energy Conservation Service.

TABLE VIII

BURNING HOURS PER MONTH

PHOTOCELL CONTROLLED LIGHTING

This table shows the hours per month that photocell controlled lighting will burn based on all night and sunset to 11 p.m. operation, seven days a week. Less than seven-day-per-week use can be apportioned accordingly.

Month	Until 11 p.m.	All night	Sunset to sunrise
January	175	425	443
February (28 days)	142	355	371
March	139	354	372
April	119	303	320
May	108	279	297
June	94	252	269
July	99	269	287
August	116	301	319
September	136	331	348
October	165	383	401
November	177	404	421
December	188	437	455
Annual total	1,658	4,093	4,303

SOURCE: Pacific Gas and Electric Company.

TABLE IX

EFFICIENCY OF NEW BOILERS

This table provides reasonable estimates of the efficiency of various typical new boilers in converting fuel energy to heating energy. Specific boilers may increase this efficiency. This figure is comparable to the combustion efficiency measured by flue gas testing.

Boiler	Efficiency
Gas-fired	76%
Oil-fired	80%
Coal-fired (stoker)	82%

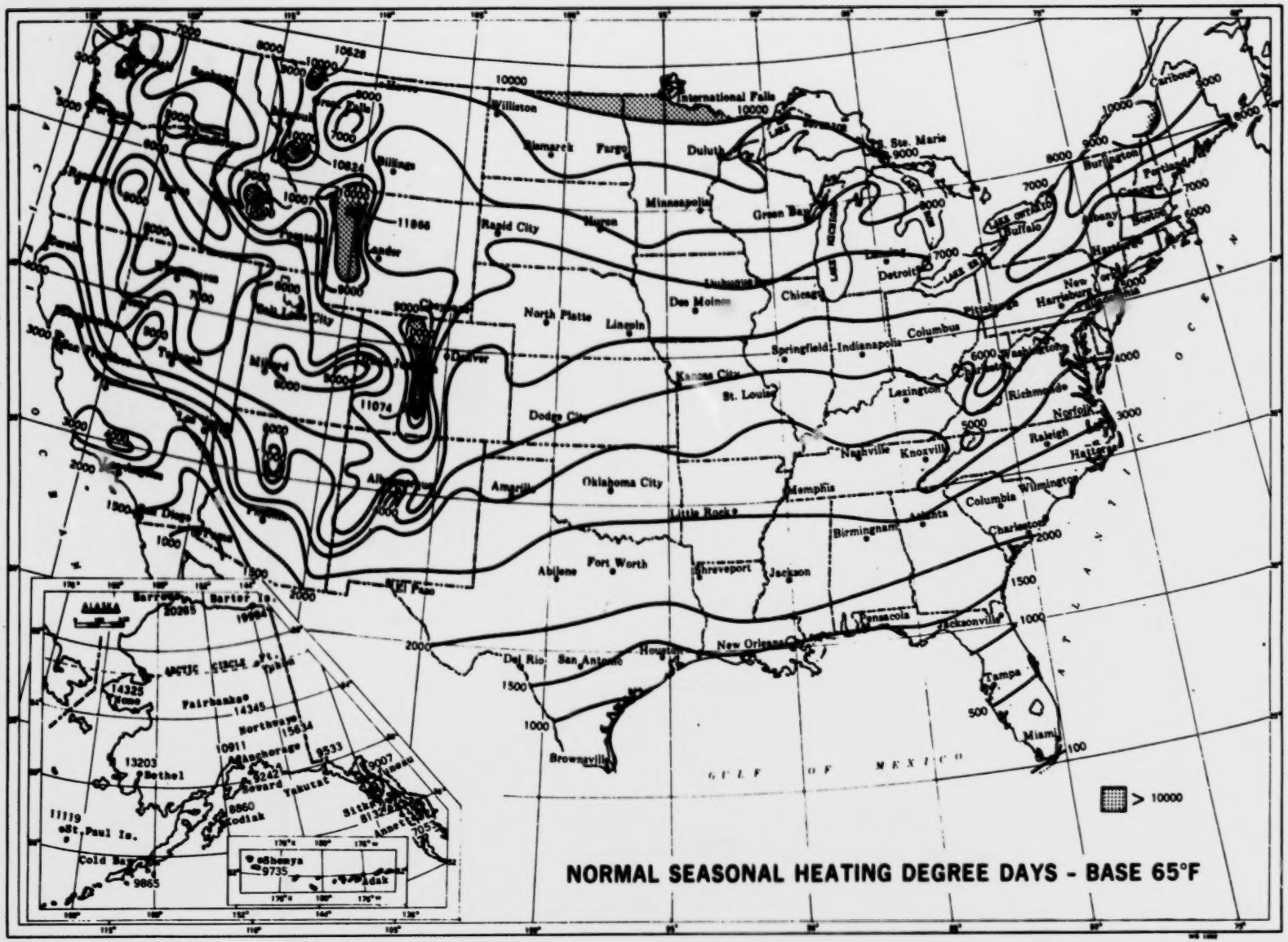
SOURCE: Public Schools Energy Conservation Service.

TABLE X

DAILY WATER REQUIREMENTS

Building use	Gallons per day per capita
Office	3
School	3
Kitchen*	3.0 gallons per meal
Apartments	25
Hospitals	50
Hotels	25
Other residential nonhousekeeping	20
Athletic facility with showers	9

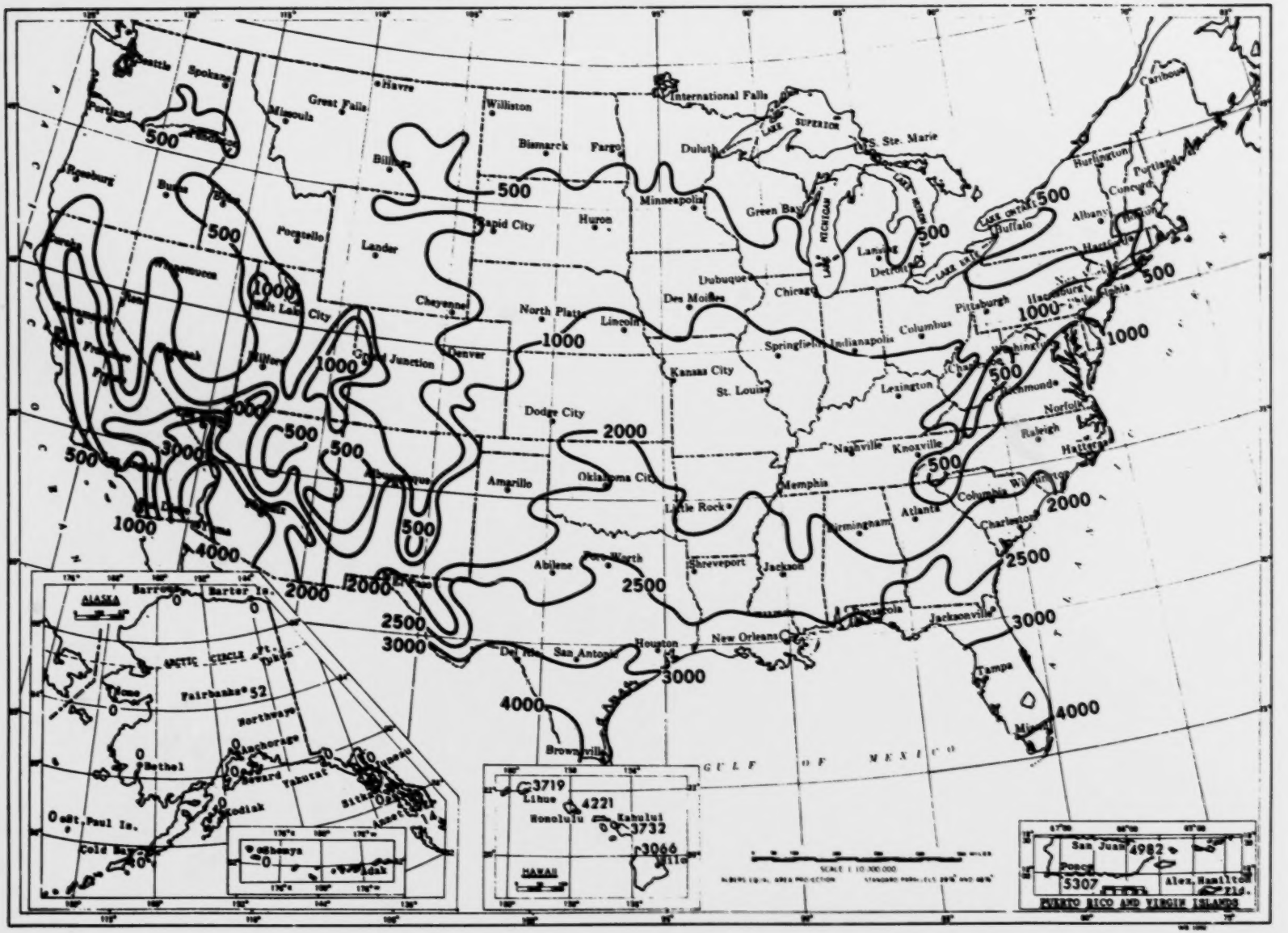
SOURCE: Federal Energy Administration. Guidelines for Saving Energy in Existing Buildings, ECM 1, p. 142.



Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration

2-102.

MEAN ANNUAL TOTAL COOLING DEGREE DAYS (BASE 65°F)



Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration

SECTION III: ENERGY MANAGEMENT WORKBOOK

INTRODUCTION

This section, the Energy Management Workbook, together with the first two sections of the manual provide human service agencies with a comprehensive and effective Energy Management Program designed to meet three basic objectives:

1. The program is effective in saving energy and lowering energy costs.

2. The program is not "mystical," that is, it makes use of common knowledge as much as possible.

3. The program is action oriented and based on an agency helping itself.

Taken in its entirety, the Energy Management Program developed in this workbook will be effective for all but the larger and more specialized facilities. For facilities of 20,000 square feet or more, the Energy Management Team should obtain technical expertise through community volunteers or staff.

Most small facilities will need to use only portions of the program. Some program elements, such as estimating savings achieved through various actions, can be simplified.

SMALL FACILITIES ENERGY MANAGEMENT PROGRAM

A small facilities program would include the following steps and worksheets:

Step One - Obtain Agency Commitment

Worksheet 1-1: Sample Board of Directors Policy Statement
Worksheet 1-2: Proposed Energy Management Team
Worksheet 1-3: Preliminary Schedule

Step Two - Form Energy Management Team

Step Three - Gather Data

Worksheet 3-1: Community Resources
Worksheet 3-3: The Energy Inventory
- FA Series: Facility Audit
- E Series: Energy Audit
- U Series: Space Use Audit
- Action Self-Audit (A, B, C, H, HS, V and VX Series, small facilities sections)

Step Six - Develop Action Plan

Step Seven - Implement Plan

Worksheet 7-1 optional

Step Eight - Monitor Consumption

Step Nine - Evaluate Program

These are the program personnel who may participate in the energy management program:

Agency volunteer board (Board)

Energy Management Team (EMT)

Energy Management Coordinator (EMC)
Program Director
Financial Manager or bookkeeper
Operating Manager

Volunteer community resource (such as an architect/engineer)

Design professional

local United Way Energy Task Force

STEP ONE: OBTAIN AGENCY COMMITMENT

This worksheet outlines the activities of Step One of the basic Energy Management Program. As each activity is completed, it should be checked off this list. The referenced worksheets follow this page.

	Activity	Responsible
( )	Develop statement of Energy Management Program objectives and processes (Use Worksheet 1-1).	EMC
( )	Develop list of potential agency and client Energy Management Team members (Use Worksheet 1-2).	EMC
( )	Develop preliminary program schedule and milestones (Use Worksheet 1-3).	EMC
( )	Estimate program costs for staff release time (Use Worksheet 1-4).	EMC
( )	Submit statement, team schedule and release time costs to board for approval and adoption.	EMC
( )	Adopt Energy Management Program (EMP).	Board of Directors

Non-Program Activities

( )	Develop public relations aspect of EMP, including use of policy statement as basis for press release.	

SAMPLE BOARD OF DIRECTORS POLICY STATEMENT

ENERGY MANAGEMENT

The Volunteer Board recognizes the responsibility of the Agency to reduce resource waste to as low a level as is practical without compromising the basic mission of the agency; reduce the impact of the rising energy costs on agency funds; and demonstrate leadership in the community in voluntary efforts to reduce the use of critical resources, including fossil fuels.

A program of effective management of energy and other resources must be vigorously pursued to maintain a stable supporting environment for agency activities. Recognizing this need, the Board of Directors charges the Executive Director to formulate and maintain programs of effective energy management.

Further, the Board recognizes the need to support this effort by authorizing the director to form a Facility Energy Management Team composed of key program and building decision-makers. The team is empowered to develop and implement a program of improved energy management and to obtain professional advice on major capital modifications for improved energy efficiency.

Further, the Board emphasizes the importance of this effort by granting release time from normal duties to enable members of the Energy Management Team, and other personnel at their direction, to participate in this activity. The team shall make periodic progress reports to the Board and to the community.

PROPOSED ENERGY MANAGEMENT TEAM (EMT)

This worksheet identifies members of the proposed Energy Management Team (EMT). Team members must be granted release time from their regular duties to participate in the effort to improve energy management. The size and composition of the EMT should reflect the size, program and complexity of the facility, but should in no case exceed five persons.

To complete the worksheet, enter the name of the decision-makers, and obtain their commitment to serve.

1. Building director:_____ Telephone:_____
   (person in over-all control of the facility, should serve as team chairperson-energy management coordinator, if possible and appropriate)

2. Program director:_____ Telephone:_____
   (building staff member responsible for programs and for scheduling of space)

3. Building operator:*_____ Telephone:_____
   (building staff member responsible for operation and maintenance of facility and its operating systems)

4. Board volunteer:_____ Telephone:_____
   (agency board member with special interest or responsibility for this facility)

5. Community resource:_____ Telephone:_____
   (utility representative, contractor or design professional willing to volunteer time for the EMT)

OTHERS

6. Name:_____ Telephone:_____

   Role:_____

WORKSHEET COMPLETED BY:_____ Date:_____

*NOTE: In small facilities, custodian/operator active involvement is dependent on ease of obtaining release time.

PRELIMINARY SCHEDULE

This worksheet establishes preliminary milestones and target dates for the program. Before completing this sheet, the Energy Management Coordinator should be thoroughly familiar with the contents of this manual, especially the Overview and Worksheet 2-1: Detailed Program Schedule. Final scheduling will occur when the EMT has been formed.

To assist in scheduling, a minimum completion date schedule is provided.

Milestone	Minimum Completion	Target Completion
Obtain Board of Directors approval of program statement, EMT and schedule	Week 1	__/__/__
Establish EMT, detail schedule	Week 2	__/__/__
Complete energy audits	Week 4	__/__/__
Complete Action Plan sheets and obtain volunteer board approval of goals	Week 6	__/__/__
Complete implementation of Action Plan	Week 10	__/__/__
Evaluate total program	Week 52	__/__/__

WORKSHEET COMPLETED BY:_____ Date:_____

BASIC EMT COST

This worksheet is for estimating the cost for staff release time, which is the major cost in the basic EMP. Only EMT staff will receive release time (unless a custodian is able to have release time in a small facility). The effect of the EMP on operating staff and client users will be to modify energy use behavior, not to add tasks.

Information Gathering

A. Find out from billings the total expenditure for energy -- fuel and electricity -- for the past twelve months.

$_____(A)

B. Record the minimum release time per EMP member required to implement the EMP from these figures:

Small facility (up to 10,000 sq ft) = est. 5 days
Medium facility (up to 50,000 sq ft) = est. 10 days
Large facility (over 50,000 sq ft) = est. 15 days

_____days (B)

C. Estimate the daily rate for each staff member released. Add these daily rates and enter the total.

$_____/day (C)

Calculations

1. Calculate the total estimated cost of release time:

_____(B) days X $_____(C) /day = $_____(D)

2. Calculate the percentage of total energy costs that EMP costs represent:

($_____(D) ÷ $_____(A)) X 100 = _____ percent

Effective energy management should provide cost avoidance of at least 10-15 percent of current energy use each year in the future.

WORKSHEET COMPLETED BY:_____ Date:_____

STEP TWO: FORM ENERGY MANAGEMENT TEAM

This worksheet outlines the activities of Step Two of the basic Energy Management Program. As each activity is completed, it should be checked off the list. Referenced worksheets follow this page.

	Activities	Responsible
( )	Organize approved Energy Management Team	EMC
( )	Develop detailed program schedule (Use Worksheet 2-1)	EMT
	Non-Program Activities	
( )	Post notices announcing formation of the team, and ask for community help in setting and meeting goals.	
( )	Use agency newsletter to announce program and team.	

DETAILED PROGRAM SCHEDULE

This worksheet should be used to develop and document the detailed work schedule for the Energy Management Program at your facility. The sheet lists the major program activities, time allowance and person responsible. Space is left for completion date. The time estimates apply to the situation where team members are willing to give the program priority.

Activities marked with an asterisk should be undertaken only at large facilities.

Activity	By	Allow	Finish Date
STEP ONE - OBTAIN AGENCY COMMITMENT			
1. Initial program planning	EMC		__/__/__
2. Obtain Volunteer Board approval	EMC, Board		__/__/__
STEP TWO - FORM ENERGY MANAGEMENT TEAM			
1. Establish Energy Management Team	EMT	1 week	__/__/__
2. Develop detailed program schedule	EMT		
STEP THREE - GATHER DATA			
1. Identify community resources	United Way, EMT		__/__/__
2. Develop energy future study	United Way, EMC		
3. Prepare Energy Audit	Fin. Mgr.	1 week	__/__/__
4. Perform Space Use Audit	Prog. Dir.		__/__/__
5. Perform Short Facility Survey	EMT	1 week	__/__/__
6. Perform Action Self-Audit	EMT		
7. Perform Long Facility Survey*/ Obtain outside assistance	EMC, Volunteer	1 week	__/__/__

STEP TWO - FORM ENERGY MANAGEMENT TEAM — WORKSHEET 2-1

Activity	By	Allow	Finish Date
STEP FOUR - REVIEW DATA			
1. Gather all data	EMT		__/__/__
2. Perform Savings Estimate*	EMT	1 week	__/__/__
3. Select Energy Management Actions	EMT		
4. Prepare goals statement for board	EMT		__/__/__
STEP FIVE - ESTABLISH GOAL			
1. Obtain board approval of goals	EMT, Board		__/__/__
STEP SIX - DEVELOP ACTION PLAN			
1. Detail Program Action Plan	Prog. Dir.		
2. Detail O&M Plan	Oper. Mgr.	1 week	__/__/__
3. Arrange Retrofit Program (see below)	EMC		
4. Review Action Plans	EMT		
STEP SEVEN - IMPLMENT PLAN			
1. Implement Action Plan	ALL	4 weeks	__/__/__
STEP EIGHT - MONITOR CONSUMPTION	EMT	Monthly	
STEP NINE - EVALUATE PROGRAM	EMT	Quarterly	

RETROFIT PROGRAM SCHEDULE

Activity	By	Allow	Finish Date
1. Perform "Maxi-Audit"*	Des. Prof. EMT	As reqd.	___/___/___
2. Select retrofit options	Des. Prof. EMT	1 week	___/___/___
3. Prepare costs and goals statement	EMT	1 week	___/___/___
4. Obtain board approval for retrofits	Board, EMT		___/___/___
5. Implement retrofits	Des. Prof.	As reqd.	___/___/___
6. Monitor retrofit results	EMT	Monthly	
7. Evaluate retrofit program	EMT	Quarterly	

*Audit done by an architectural/engineering firm. See Glossary.

STEP THREE: GATHER DATA

This worksheet outlines the activities of Step Three of the Energy Management Program. As you complete each activity, check it off the list. Referenced worksheets follow this page.

	Activity	Responsible
( )	Identify community resources	EMT, Board
( )	Develop energy future study	EMC
( )	Prepare Energy Audit	Fin. Mgr.
( )	Perform Space Use Audit	Prog. Dir.
( )	Perform Short Facility Survey	EMT
( )	Perform Action Self-Audit	EMT
( )	Perform Savings Audit (large facilities only)	EMT, Volunteer
( )	Obtain outside assistance if required	EMC, Volunteer

Non-Program Activities

( ) Ask program volunteers for energy saving suggestions

( ) Look for opportunities to improve the management of energy used in transportation

VOLUNTEER COMMUNITY RESOURCES

You can often obtain free or nominal cost assistance developing and implementing energy management plans from local organizations and individuals such as:

1. The customer service activities of utilities
2. The architecture and engineering departments of universities
3. Technical and trade schools
4. The technical departments of community colleges
5. Major science and engineering-related employers

Unless the local United Way Task Force on Energy has prepared the way for you, it will be necessary to contact potential community resources and determine their capability and willingness to assist you. Members of your agency volunteer board may also be able to direct you to community resources.

COMMUNITY RESOURCES

NAME_____ TELEPHONE_____

ORGANIZATION_____

ASSISTANCE OFFERED_____

_____

NAME_____ TELEPHONE_____

ORGANIZATION_____

ASSISTANCE OFFERED_____

_____

NAME_____ TELEPHONE_____

ORGANIZATION_____

ASSISTANCE OFFERED_____

_____

ENERGY FUTURE STUDY

To budget for energy costs and make payback estimates for capital improvements, some feeling for the future energy situation is essential. You should bear in mind that energy costs are local in the way they behave. Some of the apparent conflict and disagreement about future energy costs and changes result from local experience being at wide variance with the over-all national view.

As a small consumer, your future will be a part of the energy future of your area. However, a general knowledge of the national energy situation is useful to temper local projections and estimates.

On this worksheet, you will develop a view of your facility's future energy costs and availability. To make this information most credible, several sources, including your own experience, will be used. In addition to your own experience as stored in your records, you will obtain the views of the state energy office, your electric utility and your fuel supplier.

A. The electric future

From electric utility or cooperative:

SOURCE_____ TELEPHONE_____

For next year (198__)

Average cost per kwh_____ Percent increase_____

If demand billed, also

Average cost per kw _____ Percent increase_____

Over the next five years (ending 198__)

Average annual percent increase in kwh cost_____

Average annual percent increase in kw cost _____

From state energy office

SOURCE_____ TELEPHONE_____

For next year (198__)

Average cost per kwh_____ Percent increase_____

Over the next five years (ending 198__)

Average annual percent increase in kwh cost_____

From agency records or utility:

Complete the table from your records for the five years ending with the present year. You may use either the total annual figures, or more simply, select a month to use as a sample of annual costs.

1. Enter the year the data represents.
2. Enter the total kwh costs for the period. If you have demand billing, this is the kwh or commodity cost only and does not include the demand charges.
3. Enter the total kwh usage for the period.
4. Calculate average cost per kwh by dividing kwh cost by kwh use.
5. For all but the first year, calculate the increase factor over the previous year by dividing each year's average cost per kwh by that of the previous year.
6. Find the five-year average increase factor by totalling the increase factors and dividing by 4.
7. Convert this to an average annual percent increase.

year	kwh cost	kwh use	average cost	increase factor

AVERAGE FACTOR _____

Percent increase = (_____ - 1.0) x 100.0 = _____
(Average factor)

B. The fuel future for _____ (primary fuel)

From state energy office:

SOURCE_____ TELEPHONE_____

For next year (198__)

Average cost per unit_____ Percent increase_____

For next five years (ending 198__)

Average annual percent increase in unit cost_____

Anticipated shortages or shortfalls_____

_____

_____

From fuel supplier:

SOURCE_____ TELEPHONE_____

For next year (198__)

Average cost per unit_____ Percent increase_____

For next five years (ending 198__)

Average annual percent increase in unit cost_____

Anticipated shortages or shortfalls_____

_____

_____

From agency records:

Complete the table from your billing records for the five years ending with the present year. You may use either annual totals or, for simplicity, select a typical month or billing as a sample for each year.

1. Enter the year the data represents.
2. Enter the total cost for the fuel.
3. Enter the total number of fuel units used.
4. Calculate the average cost per fuel unit by dividing total cost by units used.
5. For all but the first year, calculate the increase factor over the previous year by dividing each year's average unit cost by that of the previous year.
6. Find the five-year average increase factor by totalling the annual increase factors and dividing by 4.
7. Convert this to an average annual percent increase.

year	fuel cost	unit use	average cost	increase factor
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
			AVERAGE FACTOR	_____

Percent increase = (_____ - 1.0) x 100.0 = _____
(Average factor)

C. Summary of energy future

Electricity kwh cost	Average annual percent increase	
	Next Year	Next Five Years
From state energy office:	_____	_____
From utility:	_____	_____
From agency records:	_____ (Average percent)	
Best guess at future:	_____	_____

NOTE: a typical averaging process for varying estimates is

$$\text{Average} = \frac{(\text{Low est.} + 4 \times \text{middle est.} + \text{high est.})}{6}$$

Fuel cost		
From state energy office:	_____	_____
From supplier:	_____	_____
From agency records:	_____ (Average percent)	
Best guess at future:	_____	_____

Prepared by _____ Date _____

THE ENERGY INVENTORY

The Energy Inventory consists of five audits that will help the team develop an understanding of the facility, how and for what purposes energy is used, and how it might be used more wisely. The five audit procedures are:

1. The basic Facility Audit (FA Worksheet Series) gathers essential information about the building and its systems.
2. The Energy Audit (E Series) studies recent energy use and weather conditions.
3. The Space Use Audit (U Series) looks at how spaces in the facility are used.
4. The Action Self-Audit (A, B, L, S, VX, V, H, C, W, and P series) will help identify energy management deficiencies and suggest some remedial actions.
5. The optional Expanded Facility Survey (FB Series) gathers more detailed data about the plant for use in preparing estimates of savings in energy and energy cost avoidance.

The first four audits should be performed on all facilities. The Expanded Facility Survey is intended for larger, more sophisticated plants. The Action Self-Audit is keyed to facility size. These options allow you to tailor the audit procedures as much as possible to the size of the facility and the time and expertise of the Energy Management Team.

Although completing the audit sheets appears to be a complicated, perhaps intimidating task, taken individually they are not difficult -- even for a nontechnical agency staff member. Taken collectively, these audits are the basis for evaluating energy use in your facility and initiating effective energy management. Work on the details carefully; your hard work will soon be rewarded by significant energy savings.

If the size and composition of the team permit, specific audit responsibilities should be assigned as follows:

1. The basic Facility Audit and the Action Self-Audit should be performed by the entire team with other maintenance and service personnel as resources.
2. The Energy Audit should be performed by the financial manager, bookkeeper or other person with access to energy billings.
3. The Space Use Audit should be completed by the facility Program Director.
4. The expanded Facility Survey should be performed by the team with volunteer professional assistance, if possible.

The basic Facility Audit, Energy and Space Use Audits should be completed before undertaking the Action Self-Audit. A review of the former audits will be helpful during the Action Self-Audit.

Audit blanks appear on the following pages. Make extra copies of the forms first, so that several "dry runs" of each procedure can be made.

FA

FACILITY AUDIT

FOR

_____
(FACILITY)

_____
(AGENCY)

_____
(CITY, STATE)

ENERGY MANAGEMENT TEAM

_____

_____

_____

_____

_____

DATE ____/____/____

TASK FORCE ON BUILDINGS
NATIONAL ASSEMBLY OF NATIONAL VOLUNTARY HEALTH AND
SOCIAL WELFARE ORGANIZATIONS, INC.

This section provides information about the facility, its administrative staff, construction dates and other management studies.

1. Enter the name of the facility and complete the information requested on address and operating staff.

2. Select the base year for the energy management study. This is an important step. The base year is a period of twelve consecutive months used to establish an energy use line for comparison with future program results.

3. The calendar year or the fiscal year are both convenient base years. If your agency has a program year choose it as the base year. Because there is no heating in the summer, the July-based fiscal year is a convenient base year. Enter starting and ending months and years for the base year.

4. Enter the dates on which the various construction phases of the facility were completed, the contents of each phase and the architect and engineer of the phase, if known. Also enter any major remodelling activities performed. Enter only the year.

5. Enter the dates, contents and consultant of any major energy management studies made for the facility, including utility audits. Do not include routine maintenance activities.

6. Check NABC if a national agency building consultant was used during the facilities design stage.

FACILITY AUDIT
FACILITY DATA

FA

FACILITY NAME _____

ADDRESS _____

_____

ENERGY COORDINATOR _____ PHONE _____

BLDG. DIRECTOR _____ PHONE _____

BLDG. SUPT. _____ PHONE _____

ENERGY AUDIT BASE YEAR ____/____ to ____/____

CONSTRUCTION/REMODELLING:

YEAR	PORTION	ARCHITECT	NABC
_____	_____	_____	( )
_____	_____	_____	( )
_____	_____	_____	( )

ENERGY MANAGEMENT STUDIES:

DATE _____ STUDY _____

BY _____

PHONE _____

DATE _____ STUDY _____

BY _____

PHONE _____

Nonenergized systems do not use energy directly, but they do affect the amount of energy used. Examples include the building structure and physical organization as determined by walls, windows, doors, roof, floors, landscaping and orientation.

1. The area of one floor is based on the outside dimensions of the building, or the distance from the center lines of shared walls. If there are several buildings, or if the building shape is complex, compute the total area by determining the area of each section and adding them together.

   Deduct any unheated spaces such as garages and boiler rooms from the total.

2. The number of stories in the facility should represent only those levels that count toward the floor area in (1) above. For example, if the only room in a basement is an unheated boiler room not counted in (1), do not count the basement as a separate story.

3. The gross area of a building is calculated by multiplying the area of one floor by the number of stories.

4. Indicate the construction of the exterior walls in the appropriate box. If there is more than one type of exterior wall, check as many boxes as necessary, but do not consider any wall which is less than 10 percent of the total surface area.

   A "curtain wall" is usually constructed of glass and panels of aluminum or steel with a porcelain-enamel finish.

   Indicate how you judge the insulation in the wall.

   Estimate the percentage of the wall surface that is glass. The nearest ten percent is close enough. Indicate the type of glass in the wall.

5. Indicate, if possible, the material of the roof deck.

   "Tectum" is a mineral or vegetable fiber building board that looks from the bottom like petrified worm-holes or shredded wheat. It is stuctural, provides insulation and can absorb sound.

1. FLOOR AREA = _____ sq. ft.

2. NUMBER OF STORIES = _____

3. GROSS AREA (FLOOR AREA X NUMBER OF STORIES) =

_____ sq. ft.

4. EXTERIOR WALLS

NON-GLASS AREAS:
( ) WOOD
( ) BRICK,
BRICK CAVITY
( ) BRICK
VENEER
( ) CONCRETE BLOCK
( ) CONCRETE SLAB
( ) CURTAIN WALL, METAL
OR PORCELAIN EN.
( ) OTHER _____

INSULATED ( ) WELL ( ) POORLY ( ) NOT AT ALL
( ) DON'T KNOW

GLASS AREAS: APPROX. PERCENT OF WALL _____%
( ) SINGLE GLASS
( ) DOUBLE OR TRIPLE GLASS
( ) INSULATING GLASS
( ) OTHER _____

5. ROOF:
( ) WOOD DECK
( ) METAL DECK
( ) CLAY TILE
( ) TECTUM DECK
( ) CONCRETE DECK
( ) OTHER _____

INSULATED ( ) WELL ( ) POORLY ( ) NOT AT ALL
( ) DON'T KNOW

6. Indicate the types of spaces found in the facility, and which may require separate study for energy management opportunities.

7. In many of the audit and Action Plan development activities it may be necessary to use small (8 1/2" by 11" is convenient) floor plans of the facility. These plans show how each floor would look from above if a horizontal cut were made through the building about three feet above the floor line. If you have small plans, such as those used to show room locations, fire drill routes or maintenance schedules, use them; otherwise you will have to make simple sketch plans on graph paper.

   Such plans do not have to be exact, although they should show general building outline, room sizes and shapes and the relationships of the building spaces.

6. FACILITIES INCLUDED

( ) OFFICES
( ) MEETING/ACTIVITY ROOMS
( ) WORKSHOPS
( ) RESIDENTIAL ROOMS OR FLOORS
( ) CLINICAL SPACES
( ) GYMNASIUM(S)
( ) INDOOR BALL COURT(S)
( ) FIELDHOUSE - INDOOR TRACK
( ) EXERCISE ROOM(S)
( ) SHOWERS/LOCKER ROOM(S)
( ) MULTIUSE ROOMS
( ) INDOOR SWIMMING POOL
( ) OUTDOOR SWIMMING POOL
( ) AUDITORIUM
( ) OTHER _____

7. PROVIDE OR PREPARE ON 8 1/2" X 11" GRAPH PAPER SKETCH PLAN(S).

	(A) # OF FIXTURES		(B) LAMPS PER FIXTURE		(C) WATTS PER LAMP		(D) BALLAST FACTOR*	=	(E) WATTS = A X B X C X D	÷	(F) AREA (sq.ft.)	=	(G) WATTS PER SQ. FT. E ÷ F
OFFICE	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
MEETING/ACT. RM.	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
WORKSHOP	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
RESIDENTIAL RM.	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
CLINICAL SPACE	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
GYMNASIUM	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
INDOOR BALL COURT	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
FIELDHOUSE/TRACK	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
EXERCISE ROOM	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
LOCKER ROOM	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
INDOOR POOL	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____
AUDITORIUM	_____	X	_____	X	_____	X	_____	=	_____	÷	_____	=	_____

* USE 1.0 FOR INCANDESCENT SYSTEMS, 1.2 FOR OTHER TYPES.

8. LIGHTING

A. SELECT A ROOM TYPICAL OF EACH SPACE TYPE IN THE BUILDING.
B. PERFORM CALCULATIONS FOR EACH TYPE OF SPACE (USING FACING PAGE).
C. ENTER RESULTS BELOW.

SPACE	LIGHTING TYPE	WATTS PER SQUARE FOOT: OF TYPICAL SPACE	COMPARE TO STANDARD
OFFICE			2.0 - 3.5
MEETING ROOM			2.0 - 2.5
WORKSHOP			2.0 - 4.0
RESIDENTIAL			1.0 - 1.5
CLINICAL ROOM			2.0 - 3.5
GYMNASIUM			1.0 - 2.0
BALL COURT			2.0 - 3.0
FIELDHOUSE			1.0 - 2.0
EXERCISE ROOM			1.0 - 1.5
LOCKER ROOM			0.5 - 1.5
INDOOR POOL			1.0 - 2.0
AUDITORIUM (NOT INCLUDING FLOODS AND SPOTS)			0.2 - 1.0

9. Heating systems convert fuel or electricity into usable heat. The heating system in a facility may appear to be either part of the HVAC system, separate from the system but connected by pipes or ducts, or it may appear to be a complete HVAC system itself. In the latter case, Sections 2 and 3 of this Survey may be redundant.

   (a) Enter the best description of your heating system (if there are more than two such systems, copy this sheet):

   BOILER(S)
   PURCHASED STEAM
   DIRECT-FIRED FURNACE(S)
   DIRECT-FIRED PACKAGE UNIT(S)

   (b) Enter the fuel used. If your boiler is capable of using a "back-up" fuel when the primary fuel is not available, record the back-up fuel.

   (c) Enter the number of units in the heating system, e.g., the number of boilers or furnaces.

   (d) Enter the kBtu (1 kBtu = 1,000 Btus) input rating of each unit in the heating system. If you have small furnaces, enter the rating of a typical unit and don't bother looking at all of them.

   (e) Enter the results of the most recent combustion efficiency test (percent peak efficiency); if the test was made more than six months ago enter a question mark (?) after the rating.

   (f) Enter the number of weeks the heating system was used, and if shut down, the start-up and shut-down dates for the system.

10. Cooling systems provide either chilled air or chilled water (used to cool room air) to the HVAC system, or they may appear to be a self-contained HVAC system, e.g., a window unit.

   (a) Enter the best description of your cooling system:

   ABSORPTION
   ELECTRIC DRIVE
   WATER-COOLED PACKAGE UNIT
   AIR-COOLED PACKAGE UNIT
   WINDOW UNIT (actually a small air cooled package)

   (b) Complete the rest of the information requested; note that the output rating is to be provided in cooling tons.

9. HEATING SOURCES

	SYSTEM 1	SYSTEM 2
A. SYSTEM TYPE	_____	_____
B. REGULAR FUEL	_____	_____
C. BACKUP FUEL	_____	_____
D. NUMBER OF UNITS	_____	_____
E. INPUT RATING EACH	_____KBTU	_____KBTU
F. COMBUSTION EFFIC.	_____%	_____%
BASE YEAR USE	_____wks.	_____wks.
FROM	__/__/__	__/__/__
TO	__/__/__	__/__/__

10. COOLING SOURCES

A. SYSTEM TYPE	_____	_____
B. NUMBER OF UNITS	_____	_____
OUTPUT RATING	_____TONS	_____TONS
BASE YEAR USE	_____wks.	_____wks.
FROM	__/__/__	__/__/__
TO	__/__/__	__/__/__

11. For each major space category of your facility, determine the type of major heating and cooling systems. Descriptions of various systems can be found in Section II. Place an X in the appropriate box under the space types.

    For each system checked, determine if it heats, ventilates or cools.

    In some spaces, there may be a second heating system under the windows. This system, known as a "perimeter system," is used to prevent drafts forming with the cold air from the window. You should note whether there is such a system.

11. HEATING/COOLING SYSTEMS

(CHECK APPROPRIATE BOXES)

SYSTEM	HEATS	VENTILATES	COOLS	SERVES: OFFICES	MEETING ROOMS	RESIDENTIAL	WORKSHOPS	FOOD SERVICE	P.E. SPACES	MULTIUSE	POOL AREA	OTHER
TERMINAL REHEAT	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SINGLE ZONE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MULTIZONE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DUAL DUCT	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
VARIABLE VOLUME	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
INDUCTION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
HEAT PUMP(S)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FAN COIL(S)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SMALL FURNACE(S)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
RADIATOR(S)	☐			☐	☐	☐	☐	☐	☐	☐	☐	☐
PERIMETER	☐			☐	☐	☐	☐	☐	☐	☐	☐	☐
WINDOW UNITS			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
_____	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

12. SERVICE HOT WATER

HEATED BY ( ) HEATING BOILERS ( ) ELECTRIC HEATERS
( ) GAS HEATERS ( ) OIL HEATERS

HEATED TO TEMPERATURE _____ °F
A

CITY TEMPERATURE _____ °F
B

RISE °F = _____ - _____ = _____ °F
A B

13. FOOD SERVICE

MANAGER _____ PHONE _____

MEALS COOKED DAILY _____ FUEL(S) _____

KITCHEN HOURS _____ a.m. - _____ p.m.

14. LAUNDRY

MANAGER _____ PHONE _____

	FUEL	NUMBER	AVERAGE CAPACITY	WEEKLY LOADS
WASHERS	_____	_____	_____ lbs.	_____
DRYERS	_____	_____	_____ lbs.	_____

Human systems are the people, groups and activities that affect when and how much energy is used. One type of human system is the program of the agency at the facility -- how the plant is used, for what purposes, by whom and when. Another human system comprises the decision-makers and operators who run the energized systems to provide a supportive environment for the agency. It is vital to coordinate these two systems in order to provide effective energy management.

15. If the information is relevant to the agency's purposes, enter the number of persons who make daily use of the facility.

    Enter the occupied (day) and unoccupied (night) conditions maintained in the facility during the heating and cooling seasons. If some spaces have different conditions, note them on the back of the survey sheet. Relative humidity may not be readily found.

    Enter the time blocks for each day during which the facility is maintained at occupied conditions.

    Estimate the daily lighting use, both the number of hours lights are used and the percent of total lights in use at any given time.

15. OPERATIONS

PERSONS SERVED _____/DAY _____/HR.

SPACE CONDITIONS:

OCCUPIED HEATING _____°F

COOLING _____°F _____%RH

UNOCCUPIED HEATING _____°F

COOLING _____°F _____%RH

HOURS AT OCCUPIED CONDITIONS

MONDAY	_____a.m. to	_____p.m.
TUESDAY	_____a.m. to	_____p.m.
WEDNESDAY	_____a.m. to	_____p.m.
THURSDAY	_____a.m. to	_____p.m.
FRIDAY	_____a.m. to	_____p.m.
SATURDAY	_____a.m. to	_____p.m.
SUNDAY	_____a.m. to	_____p.m.

LIGHTING:

DAILY USE _____hrs. _____%

FB

EXPANDED FACILITY AUDIT

FOR

_____
(FACILITY)

_____
(AGENCY)

_____
(CITY, STATE)

PREPARED BY

_____
(NAME)

_____
(TITLE)

DATE _____/_____/_____

TASK FORCE ON BUILDINGS
NATIONAL ASSEMBLY OF NATIONAL VOLUNTARY HEALTH AND
SOCIAL WELFARE ORGANIZATIONS, INC.

The Expanded Facility Audit gathers information for preparing savings estimates (Worksheet 4-1) for various energy management actions identified in the Action Sheets. An adequate program can be developed using only the basic Energy Inventory and the Action Sheets, but the Expanded Survey should be completed if these statements apply:

1. The facility is large, or it has sophisticated spaces or systems.

2. The Energy Management Team has or can get the technical expertise to complete the survey and the estimates.

3. The team wants the survey information to refine the goals of the Energy Management Program.

Survey Procedure

1. Divide the facility into its component space types (see Facility Audit FA-6). Each component should include both the program space where the activities take place, and the support space, such as corridors and restrooms. A few examples are:

   A gymnasium and its locker rooms, offices and foyer.

   An auditorium, its stage, dressing rooms, box office, balcony and foyer.

   Offices and their corridors, storage, toilets and conference rooms.

   Small or specialized facilities may be largely or entirely of one type of space and may be treated as such even if a few rooms are another type. For example, a gymnasium may include a small office complex that need not be separated.

2. Survey each component space with the energized and nonenergized survey forms.

3. Summarize the results of all of the space surveys on the Facility Summary facing this page.

Facility Summary

From the space surveys, provide the floor area, roof, walls, lighting and HVAC information required.

Provide the information on exterior lighting and its use.

EXPANDED FACILITY AUDIT

FACILITY SUMMARY

FB DD

FLOOR	TOTAL AREA	_____	sq. ft.
ROOF	TOTAL AREA	_____	sq. ft.
	TOTAL HTF	_____	Btu/hr./°F
WALLS	TOTAL AREA	_____	sq. ft.
	TOTAL HTF	_____	Btu/hr./°F
LIGHTING	TOTAL LOAD	_____	kw

HVAC:

NORMAL ANNUAL HEATING DEGREE-DAYS	_____	
NORMAL ANNUAL COOLING DEGREE-DAYS	_____	
TOTAL SYSTEM CAPACITY.	_____	cfm
MINIMUM OUTSIDE AIR	_____	cfm
EXTERIOR LIGHTING TOTAL LOAD	_____	kw

SEASONAL USE:

WINTER	_____	hrs./day
SPRING	_____	hrs./day
SUMMER	_____	hrs./day
FALL	_____	hrs./day
ANNUAL USE	_____	hours

165

Enter the name of the component space or check the FACILITY box.

1. Enter the floor area in square feet, including all support space. Use outside dimensions to determine gross floor area. Measure from the centerline of shared walls.

2. If the space has a roof, measure as above.

   From Section II, Building Envelope, determine the U value (or best estimate) for the roof-ceiling construction and enter here. The U value measures the rate of heat transmission by the roof in Btu's per hour per degree of temperature difference between the sides of the roof.

   Calculate the space roof heat transmission factor (htf) by multiplying the U value by the roof area. This gives total heat loss through the roof per hour.

3. If the space has exterior walls, enter the area of each component of these walls, including all glass. Find the U value (or best estimate) of the solid portion of the walls.

   Calculate the heat transmission factor (htf) for each wall component.

   Total the wall area and the htf's.

EXPANDED FACILITY AUDIT

NONENERGIZED SYSTEMS

FB

SPACE _____ OR ____ FACILITY

1. FLOOR AREA = _____ sq. ft.

2. ROOF: _____ (AREA) X _____ (U value) = _____ (HTF)

3. EXTERIOR WALLS

FACING	AREA		U value		HTF
NORTH/NE					
SINGLE GLASS	_____	X	1.16	=	_____
DOUBLE GLASS	_____	X	0.61	=	_____
WALL	_____	X	_____	=	_____
EAST/SE					
SINGLE GLASS	_____	X	1.16	=	_____
DOUBLE GLASS	_____	X	0.61	=	_____
WALL	_____	X	_____	=	_____
SOUTH/SW					
SINGLE GLASS	_____	X	1.16	=	_____
DOUBLE GLASS	_____	X	0.61	=	_____
WALL	_____	X	_____	=	_____
WEST/NW					
SINGLE GLASS	_____	X	1.16	=	_____
DOUBLE GLASS	_____	X	0.61	=	_____
WALL	_____	X	_____	=	_____
TOTAL	_____ (AREA)				_____ (HTF)

167

Enter the name of the component space or check the FACILITY box.

4. Enter the total installed kw and annual use estimate of each lighting type.

   Indicate the use of natural light. There may be program reasons why natural light cannot be used, such as in a competition gymnasium.

5. Enter the heating season temperatures for occupied and unoccupied space.

6. Enter the cooling season temperatures for occupied and unoccupied space. If the facility is not cooled, leave this section blank.

7. From Facility Survey FA-11, enter the type of heating, ventilating and cooling (HVAC) system serving the space.

   If the type of system is RADIATOR(S), skip the remaining questions.

FB

SPACE _____ OR _____ FACILITY

4. LIGHTING:

	INSTALLED	ANNUAL USE
INCANDESCENT	_____ kw	_____ hrs.
FLUORESCENT	_____ kw	_____ hrs.
_____	_____ kw	_____ hrs.

NATURAL LIGHT _____ CANNOT BE / _____ CAN BE / _____ IS USED.

5. HEATING SPACE TEMPERATURES:

OCCUPIED _____ °F _____ hrs./wk.
UNOCCUPIED _____ °F

6. COOLING SPACE TEMPERATURES:

OCCUPIED _____ °F _____ hrs./wk.
UNOCCUPIED _____ °F

7. HVAC SYSTEM:

TYPE (SEE FA-11)
TOTAL CFM _____ FAN HP _____
MINIMUM OUTSIDE AIR PCT. _____ %

E

ENERGY AUDIT

FOR

_____
(FACILITY)

_____
(AGENCY)

_____
(CITY, STATE)

BASE YEAR: ___/___/___ to ___/___/___

CURRENT YEAR: ___/___/___ to ___/___/___

PREPARED BY

_____
(NAME)

_____
(TITLE)

DATE ___/___/___

TASK FORCE ON BUILDINGS
NATIONAL ASSEMBLY OF NATIONAL VOLUNTARY HEALTH AND
SOCIAL WELFARE ORGANIZATIONS, INC.

The Energy Audit provides information on the use of energy by your facility and on the local climate. Inherent in this audit is the concept of the base year. The base year is a twelve month period used for comparing energy usage to other years. More about the base year can be found on the Facility Information sheet of the Facility Survey.

In the Energy Audit, electricity and fuel data is collected for the base year and the current year. Heating information in the form of weather bureau heating degree-days is also collected. To provide some sense of where the facility stands in its energy use, indexes of kBtu (1 kBtu = 1,000 Btu) per square foot per year are created.

Begin the Energy Audit by making several copies of the audit sheets.

1. Enter the base year on one sheet and the current year on another.

   Enter the monthly electric information from your utility bill. Data should be entered in the month that the bulk of the energy use took place. For example, if the billing period was from January 20 to February 20, the data should be entered for February.

   If the plant is mechanically cooled by electric-powered equipment, obtain the cooling degree-days from the weather bureau.

   Convert the kwh's to kBtu's by multiplying by 3.413. Divide the kBtu's by the gross area (see Facility Survey FA-3) to obtain the kBtu/sq. ft./year index for each year.

ENERGY AUDIT

1. ELECTRICITY USE

E

ELECTRICITY YEAR _____

MONTH	BILLING PD. FROM	TO	KWH USE	COST	COST PER KWH	COOLING DEGREE DAYS*
JAN						
FEB						
MAR						
APR						
MAY						
JUN						
JUL						
AUG						
SEP						
OCT						
NOV						
DEC						
TOTAL					/////////	

KBTU CONVERSION	X 3.413
TOTAL KBTU	
GROSS AREA (FA-3)	÷
KBTU/GSF	

1 KBTU = 1000 Btu

1 KWH = 3,413 Btu

* ONLY IF COOLED.

2. A great deal can be learned from a graphical presentation of the base year and current year electric use data.

   Select a scale for the vertical axis that allows presentation of the monthly data collected on the electricity sheets. Enter the scale on the graph.

   Plot each month's electric use for the base and current years on the graph. Use different colors to represent the two years.

   Note that for noncooling electricity, lower consumption from year to year may indicate an effective savings program.

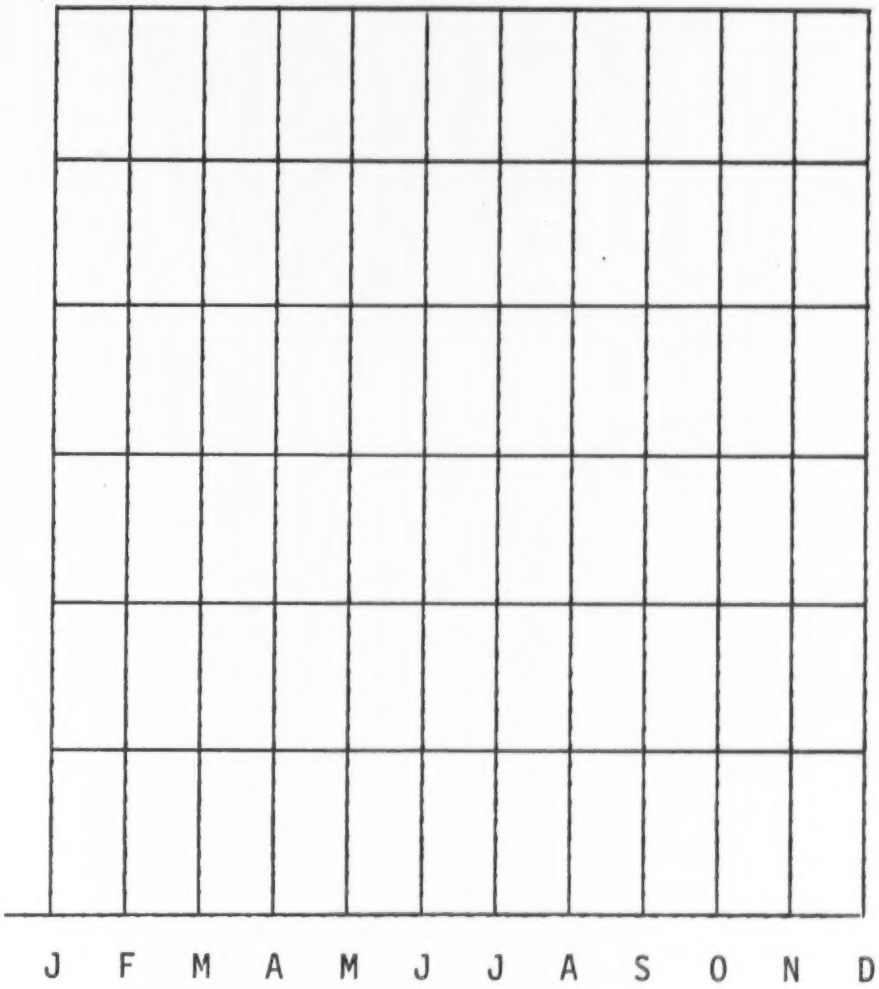
   Costs could also be plotted but the result would not be as illuminating since costs may rise without any increase in consumption.

ENERGY AUDIT

2. ELECTRICITY GRAPH

E

ELECTRICITY USE 19____ vs 19____



BASE YEAR 19____ (BLUE)

CURRENT YEAR 19____ (RED)

3. The preparation of the data on heating fuel is similar to that for electricity use (E-1).

   Enter the name of the fuel and the base and current years on separate copies of the Heating Fuel Use worksheet.

   If the fuel is natural gas, use monthly billings and provide the required information.

   If oil is used and monthly consumption records are not available, enter the deliveries in the month they were received. Remember to allow for oil in the tanks at the start and the end of the year.

   The total oil used will be equal to the quantity on hand at the start of the year, plus all deliveries, minus the quantity left at the end of the year.

   For oil, coal and propane, initiate a progam of checking the fuel used at least on the first of each month.

   To make the comparison, select the appropriate fuel energy content from those provided at the bottom of the chart. For other fuels, contact the supplier and ask for the Btu content of a unit of the fuel. Remember 1 kBtu = 1,000 Btu's.

ENERGY AUDIT

3. HEATING FUEL USE

E

FUEL _____ YEAR _____

MONTH	PERIOD FROM	PERIOD TO	UNITS USE	COST	COST PER UNIT	HEATING DEGREE DAYS
JAN						
FEB						
MAR						
APR						
MAY						
JUN						
JUL						
AUG						
SEP						
OCT						
NOV						
DEC						
TOTAL					////////	

KBTU CONVERSION	X	1 KBTU = 1000 Btu
TOTAL KBTU		1 GALLON #2 OIL = 139 KBTU
GROSS AREA (B-1)	÷	#6 OIL = 149 KBTU
KBTU/GSF		1 THERM = 100 KBTU
		1 CCF = 100 KBTU

4. For metered fuels and nonmetered fuels for which monthly records are available, plot as for electricity.

   For nonmetered fuels for which a monthly measuring program has been initiated, plot the uses as they become available.

   Also plot heating degree-days using a different type of line.

   Select a scale for fuel use which allows plotting of monthly values.

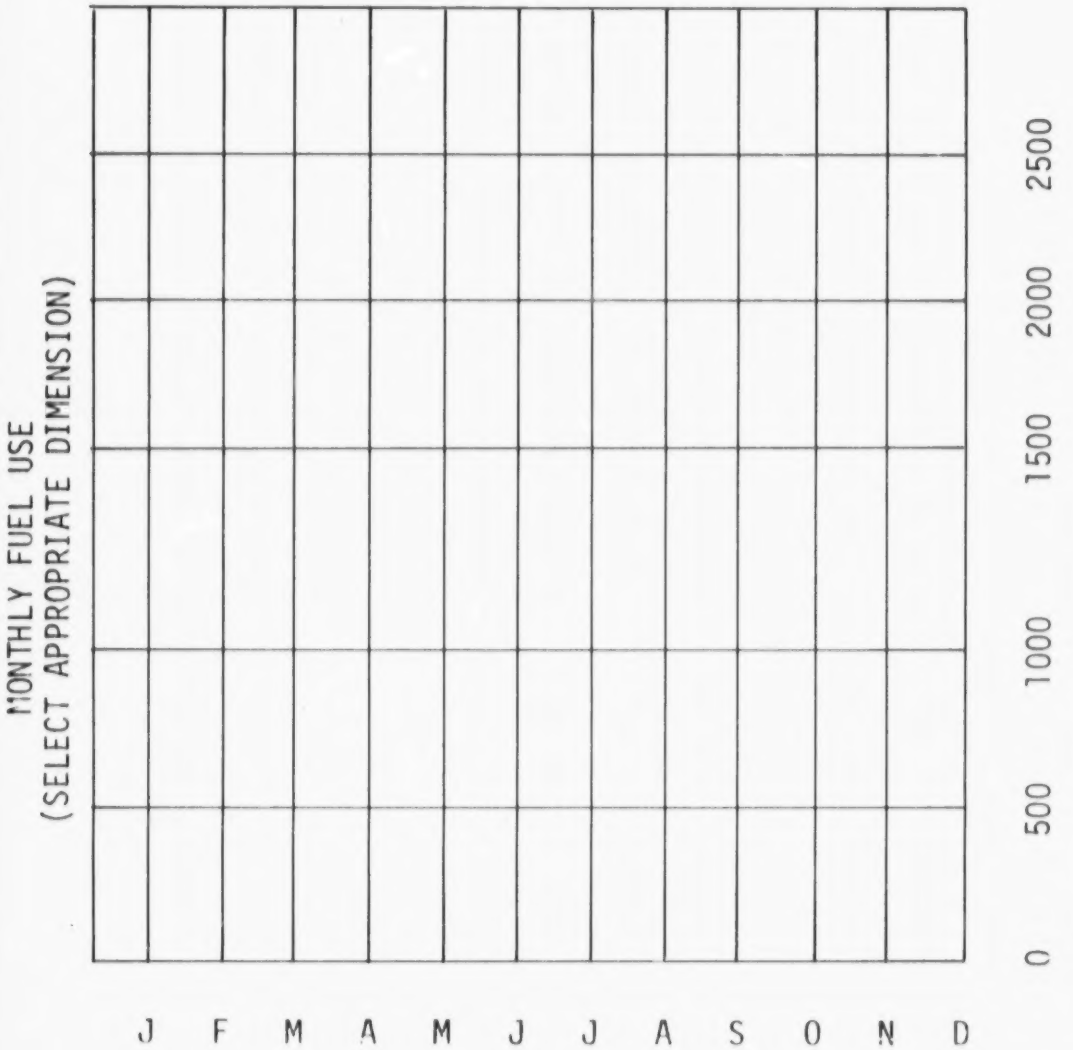
   Heating fuel use should generally follow the degree-day plot.

ENERGY AUDIT

4. HEATING FUEL GRAPH

E

FUEL _____ 19____ vs 19____



	FUEL	DEGREE DAYS
BASE YEAR 19____ (BLUE)	_____	_____
CURRENT YEAR 19____(RED)	_____	_____

SPACE USE AUDIT

FOR

_____
(FACILITY)

_____
(AGENCY)

_____
(CITY, STATE)

PREPARED BY

_____
(NAME)

_____
(TITLE)

DATE ____/____/____

TASK FORCE ON BUILDINGS
NATIONAL ASSEMBLY OF NATIONAL VOLUNTARY HEALTH AND
SOCIAL WELFARE ORGANIZATIONS, INC.

The audit of scheduled building use shows how each space or group of spaces is used on each day of the week. Each sheet contains lines for describing the use of up to nine spaces of a heating/cooling zone for one day of the week.

If your facility has an HVAC (Heating, Ventilating and Airconditioning) system, a heating/cooling zone is a subdivision of the building that can be heated and/or cooled independently of all other such zones. If your facility does not have an HVAC system, the zone concept is not useful to you and, on this worksheet, means any convenient building area, such as offices or the physical education wing.

Prepare for the Schedule Audit

1. Make enough copies of the Space Use worksheet for each space each day of the week.

2. In the first column, enter the names or room numbers of the rooms to be surveyed. Spaces with identical schedules may be grouped for convenience (be sure that schedules are in fact identical). A line is provided for corridors and another for indicating zone heating hours.

Audit Space Use Schedules

3. Place an X in the "thermostat" boxes if the rooms or groups of rooms have their own thermostats or similar controls.

4. Place an X in each time box that the room or group of rooms is scheduled for use. If you think that there is unscheduled use, enter a ? in the appropriate box.

5. Place an O in each time block along the "Zone Heating" line in which occupied heating/cooling conditions are met by the heating/cooling system. Place a U in those blocks when unoccupied conditions are maintained. If the system is shut off leave the appropriate boxes blank.

You may create and use codes to represent other criteria, but remember to keep a list of the codes and what they mean.

SPACE USE AUDIT

SCHEDULED USE

U

ZONE _____ DAY _____

ROOM	THERMOSTAT	A.M. USE 12 - 6	6 - 8	8 - 10	10 - 12	P.M. USE 12 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
CORRIDOR											

(ENTER "X" FOR USE)

(ENTER "O" FOR OCCUPIED, "U" FOR UNOCCUPIED, BLANK FOR OFF.)

ZONE HEATING

INTRODUCTION TO THE ACTION SELF-AUDIT

The Action Self-Audit helps you to survey each space in your facility to determine if energy use problems exist, to define possible remedies and to assign responsibility for solutions. The audit is based on the Action Sheets; each covers a specific problem or problem area, and includes possible remedies by improved operation and maintenance procedures, retrofits or both.

Action Sheets are working documents and permanent records of decisions and actions in several phases of the Energy Management Program. First, problem areas are identified on the Action Sheets in this phase, Step Three. Step Four develops a program of suggested solutions using the Action Sheets. In Step Six, responsibility for carrying out each remedy is assigned via the Action Sheets, and Step Seven involves implementing and completing the actions.

Action Sheets and Building Systems

Each Action Sheet is part of a group of sheets surveying one area of building construction or operation. A group of Action Sheets is called a series. There are ten series:

SERIES A: Administrative
SERIES B: Building Envelope
SERIES L: Lighting
SERIES S: Space Heating
SERIES VX: Ventilation-Exhaust
SERIES V: Ventilation*
SERIES H: Boiler Room*
SERIES C: Cooling*
SERIES W: Domestic Hot Water
SERIES P: Swimming Pool*

Series marked with an asterisk are conditional, depending whether the facility being surveyed has these features. Within each series, some sheets apply to all facilities (solid black numbers in the upper righthand corner) and some only to large facilities (outline numbers).

Action Sheets and Building Spaces

To allow for variation in size and complexity of facilities, each Action Sheet may apply to the entire facility or to a space or set of spaces within it. It is not necessary to use a separate Action Sheet for each room because problems tend to be similar in all rooms of the same sort. If there are specific problems, write the room and the problem on the back of the Action Sheet.

A guide to breaking down the facility into functionally similar spaces appears in section FA-6 of the Facility Audit section. However, use of the Action Sheets to survey building spaces is up to the individual Energy Management Team.

Using the Action Sheets

In Step Three, the Action Sheets are used to identifiy problems, by seeing if the problems described exist at the facility or in the space being surveyed. Some of the problems are easier to identify than others. Identifying some may require an outside professional or contractor. Indicate that you "will find out" later whether a problem exists after you have made an effort to discover it during the Action Self-Audit.

After selecting Action Sheets that list problems which exist in your facility, the team uses Step Four to zero in on possible solutions. The Action Sheets provide two types of solutions:

> DO THESE actions for maintenance and operations changes and low-cost retrofits with less than one year payback
>
> CONSIDER THESE options involving greater investment and longer paybacks.

DO THESE modifications should be done immediately, but CONSIDER THESE options require study by people with expertise. In most cases, DO THESE actions should be done if they apply to the facility or spaces being audited. In some cases DO THESE actions are optional (as in some lighting sheets).

If you do not think an action is a good idea, do not do it. If the facility has boilers, do not make any checks or perform any work on the boilers without qualified personnel. If no one on the building staff is qualified, consider obtaining assistance from a service contractor.

In Step Six of the EMP, responsibility for specific actions will be assigned based on the Action Sheets. The initials or name of the person responsible for implementing a specific remedy is indicated in the WHO'S IN CHARGE box and the completion date in the FINISH BY box.

In Step Seven, indicate completion of the action by checking the CK box.

MAXI AUDIT indicates the need for a design or engineering professional to study the viability of the option for your facility. It is a sophisticated WILL FIND OUT.

ADMINISTRATIVE

A1. Are space temperatures reduced during unoccupied periods?

A2. Do you need to heat or cool the building before and after normal working hours?

A3. Are control devices inspected on a regular, at least quarterly, basis?

A4. Have single setting thermostats been adjusted for change in seasons? (This applies only if the spaces are heated and cooled.)

A5. Are shades, blinds and curtains used to help insulate the building?

A6. Are unoccupied or little used spaces heated and/or cooled as if fully used?

A7. Are program and/or custodial activities scheduled outside of normal occupancy hours?

A8. Are heating/cooling conditions in lobbies, corridors, vestibules and other public areas the same as in program spaces?

A9. Are heating/cooling thermostats subject to unauthorized adjustment?

A10. Are thermostats located in or near places where space temperatures fluctuate greatly, such as near doors, windows, heating or cooling units or air outlets?

A11. Does the use of laundry, custodial and other large electrical equipment coincide with heavy electrical demand periods? (Applicable only for demand billing.)

A12. Are adequate records of equipment maintenance available?

A13. Are treated (heated) air and water discarded?

BUILDING ENVELOPE

B1. Is there efficient weatherstripping and caulking at windows, doors, exterior joints and entry of pipes into the building?

B2. Is insulation in good condition, free of water damage, and does it meet regional standards?

B3. Are there large glass areas on exterior walls?

B4. Are windows and glass poorly maintained?

B5. Do improperly aligned and operated windows and doors allow excessive infiltration (unintentional introduction of outdoor air?)

B6. Improper window and/or door alignment (continued).

B7. Is there insulation between conditioned and unconditioned spaces?

LIGHTING

L1. Are incandescent lamps used in offices, workrooms, meeting rooms, hallways and gymnasiums?

L2. Is fluorescent lighting used in offices, meeting rooms, hallways and gymnasiums?

L3. Are lights consistently left on in unoccupied areas?

L4. Are lighting fixtures and lamps clean?

L5. Where fluorescent tubes have been removed, are ballasts disconnected?

L6. Is natural lighting fully used?

L7. Is exterior lighting used?

SPACE HEATING

S1. Are space temperatures higher or lower than thermostat settings?

S2. Are the hot water radiation units - radiators, convectors, baseboards, and/or finned tube heaters - operating properly?

S3. Do hot water radiation units provide sufficient heat?

S4. Does the steam heating system operate erratically?

S5. Malfunctioning steam heating system (continued).

VENTILATION/EXHAUST

VX. Is operation of exhaust fans programmed?

VENTILATION

V1. Is an excessive quantity of outdoor air used to ventilate the building?

V2. Are outdoor air intake dampers open when building or space served is not in use?

V3. Does the temperature of air flow feel too cold during the heating season?

V4. Does the air flow feel unusually low, or is it inconsistent from one space to another?

V5. Are the outdoor air, return air and exhaust dampers sequencing properly so that the quantity of outdoor air taken is equal to the amount exhausted?

BOILER ROOM

H1. Is the boiler operating unnecessarily?

H2. Is the hot water heating system too hot during mild periods?

H3. Is boiler maintained monthly, quarterly, semi-annually and annually?

H4. Do burners have pilot lights?

H5. Is there excessive smoke and sooting from the oil burner?

H6. Do multiple boilers fire simultaneously?

H7. Are boilers faulty or inefficient?

H8. Are stack temperatures greater than about 400° F plus the average room temperature of spaces served by the boiler?

H9. Is there adequate steam, condensate and heating water pipe insulation?

H10. Is combustion air for the boiler preheated?

COOLING

C1. Is space temperature higher or lower than thermostat setting?

C2. Is the chiller operated during cold weather to provide airconditioning?

C3. Are reheat coils used to maintain zone temperatures?

C4. Do multiple airconditioning compressors start at the same time?

C5. Is the cooling line pipe and duct insulation adequate?

C6. Is the refrigeration compressor efficient?

DOMESTIC HOT WATER

W1. Is the domestic hot water system efficient?

W2. Are there restrictions on the electric hot water heating cycle?

W3. Have water saving devices been used wherever practical?

SWIMMING POOL

P1. Is heated pool water temperature appropriate for type of use?

P2. For indoor pools, is natatorium air temperature appropriate for pool water temperature?

P3. Is the indoor swimming pool energy efficient?

P4. Is the heated outdoor swimming pool energy efficient?

ENERGY MANAGEMENT ACTION SHEET

ADMINISTRATIVE

This sheet applies to: Facility ☐ Space(s) ☐

A1

Question:

To estimate savings, see Worksheet: 4-1.7

Are space temperatures reduced during unoccupied periods?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Reduce heating thermostat settings by a minimum of 10° F (at least to 55° F) at nights, over weekends and during holiday periods.	☐	☐			☐
If possible, shut heating system off completely during these periods if there is no danger of freezing.	☐	☐			☐
Shut cooling systems down entirely during unoccupied periods.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install time clocks to set back or shut down systems when facility is unoccupied.	☐	☐	☐			☐
Install an automatic energy management system to control unoccupied conditions.	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A2

Question:

To estimate savings, see Worksheet: 4-1.7

	YES	NO	WILL FIND OUT
Do you need to heat or cool the building before and after normal working hours?	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Reduce length of heating/cooling day by experimenting with later start-up times for systems. Note that many spaces do not require conditioning to full comfort levels prior to occupancy.	☐	☐			☐
Shorten heating/cooling day by turning down or shutting off heating/cooling system at start of last hour of occupancy.	☐	☐			☐
Schedule custodial activities during the normal occupancy time rather than at night.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install a time clock and adjust the setting for shorter heating and cooling day.	☐	☐	☐			☐
Install an automated energy management system.	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A3

Question:

Are control devices inspected on a regular, at least quarterly, basis?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Routinely inspect all time clocks and other controls for proper functioning, correct settings and proper set points. This should be done 1) no less than quarterly; 2) whenever there is a time change; 3) whenever there is a plant schedule change; 4) whenever there is a power outage; and 5) whenever there is a seasonal change between heating/cooling.	☐	☐			
	☐	☐			
Inspect and service all thermostats in facility at least annually. (See ACTION SHEET S-1.)	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install an automated energy management system and inspect and service this system as per manufacturer's recommendations.	☐	☐	☐			
	☐	☐	☐			

3-68

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A4

Question: *

To estimate savings, see Worksheet: 4-1.5

	YES	NO	WILL FIND OUT
Have single setting thermostats been adjusted for change in seasons? (This applies only if the spaces are heated and cooled.)	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Set all thermostats to correct seasonal temperature(s).	☐	☐			
Schedule change-overs of thermostat settings to correpond with change-overs of heating and cooling.	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace existing single setting thermostats with units having capability for separate heating and cooling settings, or consider installing a second thermostat.	☐	☐	☐			
	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A5

Question:

Are shades, blinds and curtains used to help insulate the building?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
During the heating season, close all interior shading devices -- shades, curtains, blinds, drapes -- at night to reduce heat loss. Instruct staff and post reminders.	☐	☐			☐
During the cooling season, if windows are not properly shaded, close these devices during the day to reduce solar heat gain. (Close only those devices on glass areas with incident sunlight.)	☐	☐			☐
Repair or replace damaged or missing shading devices.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install insulating shades or drapes. This can be done in phases.	☐	☐	☐			☐
Install exterior shading devices on windows of building's south side.	☐	☐	☐		19	☐

19

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A6

Question:

To estimate savings, see Worksheet: 4-1.6

Are unoccupied or little used spaces heated and/or cooled as if fully used?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
During the heating season, reduce thermostat settings to 55° F or lower in unoccupied or little used spaces.	☐	☐			☐
If there is no danger of freezing, turn off heating system in unoccupied or little used spaces.	☐	☐			☐
If some use is necessary, use spot heaters in large spaces with low occupancy, such as lobby reception desk.	☐	☐			☐
During the cooling season, shut off cooling to unoccupied and little used spaces.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install or modify control system to reduce or eliminate heating and/or cooling in unoccupied and little used spaces.	☐	☐	☐			☐
	☐	☐	☐			☐

3-71

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A7

Question:

	YES	NO	WILL FIND OUT
Are program and/or custodial activities scheduled outside of normal occupancy hours?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Reschedule and relocate off-hour activities to take optimum advantage of building's heating and cooling zoning and shut-down capabilities.	☐	☐			☐
Reschedule custodial and cleaning activities during hours of major building use whenever possible.	☐	☐			☐
Examine original assumptions and decisions regarding off-hour use of facility, and modify these patterns to increase energy efficiency.	☐	☐			☐
If possible, operate heating and cooling systems only during hours of major building use, and set systems back at end of this period. Allow building to "coast" for off-hour users.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install an automated energy management system that will control all spaces in accordance with usage.	☐	☐	☐			☐
	☐	☐	☐			☐

3-72

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A8

Question:

To estimate savings, see Worksheet: 4-1.7

Are heating/cooling conditions in lobbies, corridors, vestibules and other public areas the same as in program spaces?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Close supply air ducts, shut off radiators, disconnect or switch off electric heaters and/or lower heating set points in these areas if there is no danger of freeze up. If there is such danger, reduce heating as much as possible.	☐	☐			☐
If the building is cooled, close supply air ducts to these public spaces.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-73

201

202

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A9

Question:

To estimate savings, see Worksheet: 4-1.5

Are heating/cooling thermostats subject to unauthorized adjustment?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Install or replace locking screws to prevent tampering.	☐	☐			☐
Reset thermostats to correct settings.	☐	☐			☐
Install tamper-proof locking covers on thermostats.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install preset solid state electric thermostats if existing control system is electric	☐	☐	☐			☐
Relocate thermostats where they are inaccessible to space users.	☐	☐	☐			☐

3-74

ENERGY MANAGEMENT ACTION SHEET

ADMINISTRATIVE

This sheet applies to: Facility ☐ Space(s) ☐

A10

Question:

Are thermostats located in or near places where space temperatures fluctuate greatly, such as near doors, windows, heating or cooling units or air outlets?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

See below.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			
☐	☐			
☐	☐			
☐	☐			
☐	☐			

ALSO, CONSIDER THESE:

Relocate thermostats to locations where temperatures are more representative of space conditions.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			
☐	☐	☐			

3-75

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A11

Question:

Does the use of laundry, custodial and other large electrical equipment coincide with heavy electric demand periods? (Applicable only for demand billing.)

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

Establish and enforce guidelines for the use of electrical equipment to avoid concentration of demand.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			
☐	☐			
☐	☐			
☐	☐			
☐	☐			

ALSO, CONSIDER THESE:

Install a demand control system to automatically monitor power demand and shut off secondary loads to lower demand to desired levels.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			
☐	☐	☐			

3-76

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) ADMINISTRATIVE

A12

Question:

Are adequate records of equipment maintenance available?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
For plants with boilers, maintain a boiler log that includes input and output rating(s), fuel(s) used, maintenance schedule, start-up and shut-down dates and a daily record of fuel used, weather, boiler operations and maintenance and service.	☐	☐			
Using nameplate data, prepare a list of all motors and pumps in the facility and the schedule of routine maintenance for each.	☐	☐			
See Worksheet 7-1.	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace all worn and inefficient equipment with more efficient units.	☐	☐	☐			
	☐	☐	☐			

3-77

ENERGY MANAGEMENT ACTION SHEET

ADMINISTRATIVE

This sheet applies to: Facility ☐ Space(s) ☐

A13

Question:

	YES	NO	WILL FIND OUT
Are treated (heated) air and water discarded?	☐	☐	☐

IF YES, DO THESE:

See below.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			☐
☐	☐			☐
☐	☐			☐
☐	☐			☐
☐	☐			☐

ALSO, CONSIDER THESE:

Investigate heat recovery systems. Such systems are sophisticated, and their cost and effectiveness are highly dependent on building and heating/cooling system characteristics. They should not be considered without professional guidance.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			☐
☐	☐	☐			☐

3-78

211

212

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BUILDING ENVELOPE

B1

Question:

Is there efficient weatherstripping and caulking at windows, doors, exterior joints and entry of pipes into the building?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Weatherstrip and/or caulk at these points with quality materials.	☐	☐			
Cover all window and through-the-wall airconditioning units when not in use. Consider removing them during the heating season and closing the openings with insulated panels.	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
In areas with strong constant winds, install wind screens to protect exterior doors from the direct force of prevailing winds.	☐	☐	☐			
Consider other external shading devices, such as shrubbery and trees.	☐	☐	☐			

3-79

ENERGY MANAGEMENT ACTION SHEET

BUILDING ENVELOPE

This sheet applies to: Facility ☐ Space(s) ☐

B2

Question:

To estimate savings, see Worksheet: 4-T.13

Is insulation in good condition, free of water damage, and does it meet regional standards?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Inspect all insulation for water damage. If damaged, replace or repair. Replace roofs to prevent future damage.	☐	☐			
Verify that the vapor barrier of the insulation is "on the warm side," that is, toward the treated space.	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Add new insulation to meet required regional standards.	☐	☐	☐			
	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BUILDING ENVELOPE

B3

Question:

To estimate savings, see Worksheet: 4-1.14

	YES	NO	WILL FIND OUT
Are there large glass areas on exterior walls?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
When replacing broken windows, replace them with thermopanes using the same casings.	☐	☐			
See ACTION SHEET A-5 for use of blinds and curtains.	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Add reflective or heat absorbing film to minimize solar gain in summer and heat loss in winter; use of these materials requires professional study as they may result in over-all increase in energy use.	☐	☐	☐			
Install either fixed or adjustable outdoor shading devices to maximize solar gain in winter and minimize it in summer.	☐	☐	☐			
Replace all or part of each glass area with insulated brick, block walls or panels of suggested R value.	☐	☐	☐			
Replace glass areas with double or triple glass units or thermopane insulating glass.	☐	☐	☐			

3-81

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BUILDING ENVELOPE

B4

Question:

Are windows and glass poorly maintained?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Replace all broken and cracked glass.	☐	☐			☐
See ACTION SHEET B-1 for weatherstripping.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-82

ENERGY MANAGEMENT ACTION SHEET

BUILDING ENVELOPE

B5

This sheet applies to: Facility ☐ Space(s) ☐

Question:

Do improperly aligned and operated doors and windows allow excessive infiltration (unintentional introduction of outdoor air)?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Realign or rehang doors and windows that do not close properly; in extreme cases consider permanent sealing of windows.	☐	☐			
Insure that all automatic door closers are working properly and adjust for faster return when possible.	☐	☐			
Replace or repair faulty gaskets in garage and other overhead doors.	☐	☐			
See ACTION SHEET B-1 for weatherstripping.	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Resize exterior doors, especially delivery doors, making them smaller to reduce excessive air introduction when open.	☐	☐	☐			
Install self-closing doors on openings to unheated spaces. (Check with fire marshal.)	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

BUILDING ENVELOPE

This sheet applies to: Facility ☐ Space(s) ☐

B6

Question:

Improper window and/or door alignment (continued).

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

See below.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			
☐	☐			
☐	☐			
☐	☐			
☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install switches on overhead doors to prevent heating/cooling system from operating while doors are open.	☐	☐	☐			
Install vestibules at major entrances; this is most useful in climates with cold and/or long winters. (Check local fire and safety codes.)	☐	☐	☐			

3-84

ENERGY MANAGEMENT ACTION SHEET

BUILDING ENVELOPE

B7

This sheet applies to: Facility ☐ Space(s) ☐

Question:

Is there insulation between conditioned and unconditioned spaces?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

See below.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			
☐	☐			
☐	☐			
☐	☐			
☐	☐			

ALSO, CONSIDER THESE:

Install insulation that meets required regional standards behind walls and under floors separating conditioned and unconditioned spaces.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			
☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

LIGHTING

L1

This sheet applies to: Facility ☐ Space(s) ☐

Question:

To estimate savings, see Worksheet: 4-1.8

Are incandescent lamps used in offices, workrooms, meeting rooms, hallways and gymansiums?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Where appropriate, replace existing lamps with incandescent lamps of lower wattage rating; considerable change in energy use can often be accomplished with no appreciable change in lighting level.	☐	☐			☐
Where possible, use a single lamp of lower wattage in place of two incandescent lamps of combined higher wattage.	☐	☐			☐
Discontinue use of less efficient extended-life lamps except where short lamp life is a major problem.	☐	☐			☐
Discontinue using multi-level lamps, replacing each with a single level lamp rated at the lower or middle rating of the multi-level.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace nondecorative incandescent lighting with more efficient systems such as fluorescents in general use areas and mercury halide in gyms.	☐	☐	☐			☐
	☐	☐	☐			☐

3-86

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) LIGHTING

L2

Question:

To estimate savings, see Worksheet: 4-1.10

	YES	NO	WILL FIND OUT
Is fluorescent lighting used in offices, meeting rooms, hallways and gymnasiums?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Remove lamps in pairs from fixtures until a lower but still acceptable level of lighting is achieved; more tubes may be removed where lighting is general in function than where it is task oriented.	☐	☐			☐
Replace burned out lamps with lower wattage/higher efficiency lamps, such as "watt misers."	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install more efficient fluorescent tubes and ballasts in all existing fixtures that are still required for illumination.	☐	☐	☐			☐
Replace existing lighting systems with more efficient systems.	☐	☐	☐			☐

3-87

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) LIGHTING

L3

Question:

To estimate savings, see Worksheet: 4-1.12

	YES	NO	WILL FIND OUT
Are lights consistently left on in unoccupied areas?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Instruct users to turn off lights when leaving space; support instruction with signs and other motivating devices.	☐	☐			☐
Organize activities to minimize use of lights.	☐	☐			☐
Where possible, use multiple bank switching to use only minimum amount of light needed.	☐	☐			☐
Instruct custodians and administrative personnel to turn off lights in all empty rooms on their regular or incidental rounds.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Rewire switches to allow more local control of lights.	☐	☐	☐			☐
Install timer switches which automatically turn lights off after a preset period.	☐	☐	☐			☐

3-88

ENERGY MANAGEMENT ACTION SHEET

LIGHTING

L4

This sheet applies to: Facility ☐ Space(s) ☐

Question:

Are lighting fixtures and lamps clean?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Establish a regular inspection and cleaning schedule for lamps and fixtures. Dust and dirt build-up reduce lighting effectiveness.	☐	☐			
Replace yellowed or hazy lenses with new acrylic lenses that do not yellow.	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace old luminaires (fixtures) with new types that have higher light output and are easier to clean.	☐	☐	☐			
	☐	☐	☐			

3-89

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) LIGHTING

L5

Question:

To estimate savings, see Worksheet: 4-1.10

Where fluorescent tubes have been removed, are ballasts disconnected?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF NO, DO THESE:

If removal is considered permanent, disconnect ballasts serving removed tubes.	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

Instead of removing tubes, replace them with dummy or "phantom" tubes.	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
	☐	☐	☐			☐
	☐	☐	☐			☐

3-90

ENERGY MANAGEMENT ACTION SHEET

LIGHTING

L6

This sheet applies to: Facility ☐ Space(s) ☐

Question:

	YES	NO	WILL FIND OUT
Is natural lighting fully used?	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Use natural light whenever possible. Leave lights off in spaces with adequate natural light.	☐	☐			
Schedule daytime activities whenever possible into spaces with access to natural light.	☐	☐			
Clean windows regularly.	☐	☐			
Clean walls and when repainting use light reflective nonglossy colors.	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install light sensing and dimming equipment which will automatically compensate for natural light conditions.	☐	☐	☐			
Rewire switches in meeting rooms and other spaces with access to natural light to permit partial use of lights.	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) LIGHTING

L7

Question:

To estimate savings, see Worksheet: 4-1.11

	YES	NO	WILL FIND OUT
Is exterior lighting used?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Replace exterior flood lamps with lamps of lower wattage where practical.	☐	☐			☐
Eliminate outdoor lighting where practical.	☐	☐			☐
Establish hours of outdoor lighting by season, month and purpose of lighting, and reset lighting clock or schedule to these hours; remember that darkness comes later in summer and ends earlier than in winter.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install control devices such as time clocks or photocells to turn lights on and off automatically; establish schedule for seasonal resetting of time clocks.	☐	☐	☐			☐
Replace exterior incandescent lamps with more efficient types such as sodium vapor or mercury halide.		☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) SPACE HEATING ☐

S1

Question:

To estimate savings, see Worksheet: 4-1.5, 4-1.18

	YES	NO	WILL FIND OUT
Are space temperatures higher or lower than thermostat settings?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Recalibrate thermostat(s).	☐	☐			☐
If pneumatic system, blow out moisture, oil and dust from pneumatic lines; if electric system, clean contacts.	☐	☐			☐
Recalibrate controllers.	☐	☐			☐
Verify that control valves and dampers, if present, are modulated properly, and adjust if necessary.	☐	☐			☐
Verify that heat generating device is producing heat and that distribution to the space is unobstructed.	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
For electric control systems, install preset solid state thermostats that do not require calibration.	☐	☐	☐			☐
	☐	☐	☐			☐

3-93

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) SPACE HEATING

S2

Question:

Are the hot water radiation units -- radiators, convectors, baseboards and/or finned tube heaters -- operating properly?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Open air vents and bleed off air until water appears.	☐	☐			☐
Repair or replace faulty valves.	☐	☐			☐
Verify that the hot water pump or booster pump is working; repair or replace as necessary.	☐	☐			☐
See ACTION SHEET S-1 for thermostatic controls.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-94

ENERGY MANAGEMENT ACTION SHEET

SPACE HEATING

This sheet applies to: Facility ☐ Space(s) ☐

S3

Question:

Do hot water radiation units provide sufficient heat?	YES ☐	NO ☐	WILL FIND OUT ☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Correct (raise) boiler temperature if required.	☐	☐			☐
Establish a systematic cleaning schedule.	☐	☐			☐
Remove items obstructing discharge outlets.	☐	☐			☐
See ACTION SHEET S-1 for thermostatic controls.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-95

ENERGY MANAGEMENT ACTION SHEET

SPACE HEATING

This sheet applies to: Facility ☐ Space(s) ☐

S4

Question:

	YES	NO	WILL FIND OUT
Does the steam heating system operate erratically?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Evaluate the condition of the steam trap and take appropriate action; to do this, feel the steam pipe downstream of the trap.	☐	☐			
If the pipe is excessively hot, steam is probably passing through the trap. This may be caused by dirt in the trap, a valve off stem, too much steam pressure or worn trap parts.	☐	☐			
If the pipe is moderately hot (like a hot water pipe), the trap is probably functioning properly.	☐	☐			
If the pipe is cold, the trap is not working and should be repaired or replaced.	☐	☐			
Eliminate low spots in steam lines where water may be collecting and obstructing steam flow.	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			
	☐	☐	☐			

3-96

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) SPACE HEATING

S5

Question:

Malfunctioning steam heating system (continued).

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Check or replace thermostatic control valves on radiators or other steam equipment.	☐	☐			☐
Check the air vent valve and replace if necessary.	☐	☐			☐
If thermostatic trap is malfunctioning, clean or replace the bellows element.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

240

250

ENERGY MANAGEMENT ACTION SHEET

VENTILATION/EXHAUST

VX

This sheet applies to: Facility ☐ Space(s) ☐

Question:

Is operation of exhaust fans programmed?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Discontinue use of unnecessary exhaust fans.	☐	☐			☐
Rewire toilet room exhaust fans to operate only when lights are on. (These fans are often wired to operate when the lights are off.)	☐	☐			☐
Establish schedules so that exhaust fans operate only when needed.	☐	☐			☐
Limit smoking to specific areas and group these areas with others of similar exhaust requirements so that they may be served by one exhaust system.	☐	☐			☐
Verify operation of dampers in exhaust ducts; repair or replace if necessary.	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install time clocks or other controls to shut off exhaust system when not needed. (Check local codes.)	☐	☐	☐			☐
Install controlled or gravity dampers on all exhaust ducts to close ducts when fan is not operating.	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) VENTILATION

V1

Question:

To estimate savings, see Worksheet: 4-1.16

Is excessive outdoor air used to ventilate the building?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Check local codes and adjust outdoor air dampers to reduce outdoor air quantities to the minimum allowed by codes.	☐	☐			☐
Consider restricting smoking to limited areas and reducing fresh air supply to code standards for nonsmoking spaces (about 50 percent reduction).	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace old-style dampers with new high-quality opposed-blade models with better close-off ratings.	☐	☐	☐			☐
For through-the-wall fan coils (also known as unit ventilators), close off the outside air intake and let infiltration at doors and windows provide outside air requirements.	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) VENTILATION

V2

Question:

To estimate savings, see Worksheet: 4-1.17

Are outdoor air intake dampers open when building or space served is not in use?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Close outdoor air dampers when area served is not in use; be sure that dampers seal properly.	☐	☐			☐
Close outdoor air dampers during morning warm-up; this is known as a "warm-up cycle" and is a normal operation for many HVAC systems.	☐	☐			☐
If codes permit, close outdoor air dampers during the last hour of space use.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install controls which automatically close dampers during unoccupied periods.	☐	☐	☐			☐
	☐	☐	☐			☐

3-100

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) VENTILATION

V3

Question:

Does the temperature of air flow feel too cold during the heating season?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
If local codes permit, raise supply air temperature to 60° F in interior zones and to 65° F in perimeter zones during heating season. Reset to cooling temperatures during cooling season.	☐	☐			
If codes permit, reduce air volume to prevent a draft effect during the heating season (See ACTION SHEET V-1).	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			
	☐	☐	☐			

3-101

257

250

ENERGY MANAGEMENT ACTION SHEET

VENTILATION

V4

This sheet applies to: Facility ☐ Space(s) ☐

Question:

Does the air flow feel unusually low, or is it inconsistent from one space to another?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Use access openings to check for obstructions in ductwork such as loose insulation, loose turning vanes and accessories and closed fire and volume dampers. Adjust, repair or replace as necessary.	☐	☐			☐
Clean or replace dirty or ineffective filters on a regular basis.	☐	☐			☐
Post signs warning users not to place obstructions in front of diffusers, registers and grilles.	☐	☐			☐
Consider rebalancing system.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-102

ENERGY MANAGEMENT ACTION SHEET

VENTILATION

V5

This sheet applies to: Facility ☐ Space(s) ☐

Question:

Are the outdoor air, return air and exhaust dampers sequencing properly so that the quantity of outdoor air taken in is equal to the amount exhausted?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Adjust damper leakage.	☐	☐			☐
Verify proper operation of damper motors.	☐	☐			☐
Adjust position indicators to show actual damper position.	☐	☐			☐
Reset linkage or replace dampers if blades do not close tightly.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace old-style dampers with new high-quality opposed-blade models with better close-off rating.	☐	☐	☐			☐
	☐	☐	☐			☐

3-103

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H1

Question:

Is the boiler operating unnecessarily?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Turn boiler off when not needed for heating spaces or domestic hot water.	☐	☐			
It may be possible to turn boilers off at night and pump unheated water through them to protect against freezing. Such operations should be attempted only if staff is certain no damage to the boilers or building will ensue.	☐	☐			
When shut-down is not possible, operate boilers at lowest firing rate or pressure during unoccupied periods.	☐	☐			
Where boiler is required to heat domestic hot water outside of the heating season, operate it no more than four hours a day or until water line temperature is reached.	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
If boiler is only source of domestic hot water, install local direct-fire or electric hot water heaters.	☐	☐	☐			
Install time clock or similar control to shut boiler down at end of heating day and to bring it back on line before the start of the next heating day.	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H2

Question:

Is the hot water heating system too hot during mild periods?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Inspect, repair and adjust reset controls.	☐	☐			☐
Experiment with lowering hot water temperature until system can just meet demands.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install automatic temperature controls to schedule heating water temperature according to outside temperature.	☐	☐	☐			☐
	☐	☐	☐			☐

285

285

ENERGY MANAGEMENT ACTION SHEET

BOILER ROOM

This sheet applies to: Facility ☐ Space(s) ☐

H3

Question:

To estimate savings, see Worksheet: 4-1.20

Is boiler maintained monthly, quarterly, semi-annually and annually?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF NO, DO THESE:

Perform this routine boiler maintenance at least once a year:	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
1. Remove scale deposits, sediments and boiler compounds from water side of boiler.	☐	☐			
2. Clean soot, fly ash and slag from burner area. 3. Check, adjust, repair and/or replace all valves and controls. 4. Measure and adjust combustion efficiency. 5. Check, adjust, repair and/or replace all burner controls.	☐	☐			
Test and adjust combustion efficiency (flue gas analysis) at least twice a year, preferably monthly.	☐	☐			
Inspect, adjust, repair and/or replace boiler auxiliary pumps and fans annually, or preferably, more often.	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Purchase flue gas analysis kit to allow frequent testing and adjustment of combustion efficiency.	☐	☐	☐			
	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H4

Question:

To estimate savings, see Worksheet: 4-1.19

	YES	NO	WILL FIND OUT
Do burners have pilot lights?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Turn burner fuel supply and pilot lights off when no further use of burner is anticipated.	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace pilot lights with electronic intermittent ignition devices to save fuel.	☐	☐	☐			
	☐	☐	☐			

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H5

Question:

To estimate savings, see Worksheet: 4-1.20

	YES	NO	WILL FIND OUT
Is there excessive smoke and sooting from the oil burner?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Inspect burner nozzles for wear, dirt and incorrect spray angles; clean, repair or replace and adjust as required.	☐	☐			☐
Verify that oil is flowing freely and that oil pressure is correct; adjust as needed.	☐	☐			☐
See ACTION SHEET H-3 for flue gas analysis.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-108

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H6

Question:

Do multiple boilers fire simultaneously?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Do not fire a boiler until it is required to provide its part of the combined boiler load.	☐	☐			☐
Isolate boiler not being fired by turning off valves.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install automatic staging controls.	☐	☐	☐			☐
	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

BOILER ROOM

This sheet applies to: Facility ☐ Space(s) ☐

H7

Question:

To estimate savings, see Worksheet: 4-1.20

	YES	NO	WILL FIND OUT
Are boilers faulty or inefficient?	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Remove scale deposits, sediment accumulation and boiler compounds on water side surfaces; examine and treat susceptible rear portion of boiler.	☐	☐			☐
Remove soot from tubes.	☐	☐			☐
If the fire does not cut off immediately when the burner shuts down, inspect solenoid valve and repair or replace.	☐	☐			☐
Inspect all boiler insulation, refractory brickwork and castings for hot spots and air leaks; repair and seal.	☐	☐			☐
See ACTION SHEET H-3 for flue gas analysis.	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Replace dangerous, ineffective and/or inefficient boilers with more efficient modular type units. When replacing, size new boilers for reduced energy standards.	☐	☐	☐			☐
If applicable, install baffle-type devices (turbulators) in tubes to improve efficiency.	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H8

Question:

To estimate savings, see Worksheet: 4-1.20

Are stack temperatures greater than about 400° F plus the average room temperature of spaces served by the boiler?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Verify that adequate air for proper combustion is available in the boiler room.	☐	☐			☐
Clean air intake filters for boiler room.	☐	☐			☐
Perform flue gas analysis to verify proper air to fuel ratio; adjust if necessary.	☐	☐			☐
NOTE: All checks and maintenance of and modifications to boilers and their operations must be performed by qualified personnel. If there are none on the staff of the building, obtain assistance from a service contractor.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			☐
	☐	☐	☐			☐

3-111

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H9

Question:

Is there adequate steam, condensate and heating water piping insulation?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Inspect all pipe runs for broken or missing insulation, and repair or replace as required.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install new insulation to bring pipe insulation up to design specifications and energy conservation codes.	☐	☐	☐			☐
	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) BOILER ROOM

H10

Question:

Is combustion air for the boiler preheated?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

See below.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			☐
☐	☐			☐
☐	☐			☐
☐	☐			☐
☐	☐			☐

ALSO, CONSIDER THESE:

Install a heat recovery device to preheat combustion air with heat from flue gas.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			☐
☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) COOLING

C1

Question:

To estimate savings, see Worksheet: 4-1.5, 4-1.18

Is space temperature higher or lower than thermostat setting?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Recalibrate space thermostat.	☐	☐			☐
If pneumatic system, blow out moisture, oil and dirt from lines; if electric, clean contacts.	☐	☐			☐
Recalibrate controllers.	☐	☐			☐
Adjust control dampers and valve, especially the economizer cycle, for proper modulation.	☐	☐			☐
Limit outside air intake when not using economizer cycle.	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install an enthalpy-based (humidity and temperature) economizer cycle.	☐	☐	☐			☐
For electric control systems, install preset solid state thermostats.	☐	☐	☐			☐

3-114

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) COOLING

C2

Question:

Is the chiller operated during cold weather to provide airconditioning?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
If system characteristics permit, shut off cooling coils and chillers and use outside air in lieu of treated cold air.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install an enthalpy-based economizer cycle.	☐	☐	☐			☐
	☐	☐	☐			☐

285

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) COOLING

C3

Question:

Are reheat coils used to maintain zone temperatures? YES ☐ NO ☐ WILL FIND OUT ☐

IF YES, DO THESE:

If system characteristics permit, disconnect reheat coils or turn off heat source and raise the temperature of air leaving cooling coils to compensate. This is not applicable where high humidity is a problem.

YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐			☐
☐	☐			☐
☐	☐			☐
☐	☐			☐
☐	☐			☐

ALSO, CONSIDER THESE:

Convert system to variable air volume type.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			☐
☐	☐	☐			☐

3-116

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) COOLING

C4

Question:

Do multiple airconditioning compressors start at the same time?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Adjust controls to stage compressor operation properly, i.e., to load each compressor until its capacity is approached and then to call the next unit on line.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
If controls do not exist, install automatic controls to share compressor loads.	☐	☐	☐			☐
	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) COOLING

C5

Question:

Is the cooling line pipe and duct insulation adequate?

YES	NO	WILL FIND OUT
☐	☐	☐

IF YES, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Inspect all pipe runs for broken or missing insulation and replace or repair as needed.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install new insulation to bring level up to design specifications and energy conservation codes.	☐	☐	☐			☐
	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) COOLING

C6

Question:

Is the refrigeration compressor efficient?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Check refrigerant charge level and adjust equipment specifications; repair all leaks.	☐	☐			
Check for faulty or fused electrical control circuits; repair or replace as required.	☐	☐			
Verify that liquid line solenoid is not leaking or stuck open.	☐	☐			
Inspect all compressor valves and take action as required.	☐	☐			
Clean evaporation and condenser coils and liquid line strainer if clogged.	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
None practical.	☐	☐	☐			
	☐	☐	☐			

3-119

293

294

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) DOMESTIC HOT WATER

W1

Question:

To estimate savings, see Worksheet: 4-1.21

	YES	NO	WILL FIND OUT
Is the domestic hot water system efficient?	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Reset heater thermostat between 105° F and 110° F or to local codes; this may require installing a kitchen booster.	☐	☐			☐
Turn off circulating pumps when facility is not in use.	☐	☐			☐
Repair all leaks.	☐	☐			☐
Replace all damaged insulation.	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Add new insulation to heaters, lines and storage tanks.	☐	☐	☐			☐
Install small heaters either at separate locations or to maintain storage temperature when boilers are not used for space heating.	☐	☐	☐			☐

3-120

295

ENERGY MANAGEMENT ACTION SHEET

DOMESTIC HOT WATER

W2

This sheet applies to: Facility ☐ Space(s) ☐

Question:

To estimate savings, see Worksheet: 4-1.21

Are there restrictions on the electric hot water heating cycle?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF NO, DO THESE:

Use heater's "vacation cycle" for extended periods between uses.	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

Limit heating with time clock or other such device to prevent adding to peak building demand during hours of heavy electrical usage.	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
	☐	☐	☐			☐
	☐	☐	☐			☐

3-121

ENERGY MANAGEMENT ACTION SHEET

DOMESTIC HOT WATER

W3

This sheet applies to: Facility ☐ Space(s) ☐

Question:

To estimate savings, see Worksheet: 4-1.21

Have water saving devices been installed wherever practical?	YES	NO	WILL FIND OUT
	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Install inexpensive flow restrictors in lines or faucets,	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install mixing valves that predetermine water temperature.	☐	☐	☐			☐
Install solar water heating system to assist in meeting domestic hot water requirements.	☐	☐	☐			☐

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) SWIMMING POOL

P1

Question:

Is heated pool water temperature appropriate for type of use?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
For recreational swimming, set pool water at 75°F to 78°F.	☐	☐			☐
For competitive swimming, set pool water at 72°F to 75°F.	☐	☐			☐
For therapy pool, use desired water temperature.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

None practical.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			☐
☐	☐	☐			☐

3-123

ENERGY MANAGEMENT ACTION SHEET

SWIMMING POOL

This sheet applies to: Facility ☐ Space(s) ☐

P2

Question:

For indoor pools, is natatorium air temperature appropriate for pool water temperature?

YES	NO	WILL FIND OUT
☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
For non-therapy pools, set air temperature at 3°F to 5°F above pool water temperature.	☐	☐			
For therapy pools, contact engineer or pool consultant for proper water-air temperature relationship.	☐	☐			
Verify that relative humidity in natatorium is within recommended 50 percent to 60 percent range.	☐	☐			
	☐	☐			
	☐	☐			

3-124

ALSO, CONSIDER THESE:

None practical.

YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
☐	☐	☐			
☐	☐	☐			

303

304

ENERGY MANAGEMENT ACTION SHEET

This sheet applies to: Facility ☐ Space(s) SWIMMING POOL

P3

Question:

	YES	NO	WILL FIND OUT
Is the indoor swimming pool energy efficient?	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Perform all BUILDING ENVELOPE ACTION SHEETS on pool enclosure.	☐	☐			
Perform all BOILER ROOM ACTION SHEETS on pool heater or heating boiler.	☐	☐			
Verify with professional engineer or pool consultant that the relationship of pool temperature, space temperature and humidity and ventilation is optimum for energy efficiency.	☐	☐			
	☐	☐			
	☐	☐			

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Install a floating pool cover to reduce evaporation and heat loss.	☐	☐	☐			
	☐	☐	☐			

3-125

ENERGY MANAGEMENT ACTION SHEET

SWIMMING POOL

This sheet applies to: Facility ☐ Space(s) ☐

P4

Question:

	YES	NO	WILL FIND OUT
Is the heated outdoor swimming pool energy efficient?	☐	☐	☐

IF NO, DO THESE:

	YES	NO	WHO'S IN CHARGE?	FINISHED BY	CK
Perform all BOILER ROOM ACTION SHEETS on pool heater or heating boiler.	☐	☐			☐
Clean pool filters as required on a regular schedule.	☐	☐			☐
Install a floating pool cover to reduce evaporation and heat loss. Although investment is involved, payback is typically in a few months, and energy savings are considerable.	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

ALSO, CONSIDER THESE:

	YES	NO	MAXI AUDIT	WHO'S IN CHARGE?	FINISHED BY	CK
Provide wind breaks to reduce rate of air flow across surface of pool.	☐	☐	☐			☐
Consider installing solar pool heating equipment.	☐	☐	☐			☐

3-126

STEP FOUR: REVIEW DATA

This worksheet outlines the activities of Step Four of the Energy Management Program. Check off each activity as it is completed. The referenced worksheets follow this page. Note that some activities apply only to large facilities.

	Activity	Responsible
( )	*Prepare savings estimates for Action Questions identified on Action Self-Audit Sheets (use Worksheet Series 4-1).	EMT, Volunteer
( )	*Prepare Cost-Benefit Analysis for capital modifications (use Worksheet 4-2).	EMT, Volunteer
( )	Identify Action Plan recommendations to be carried out based on Action Self-Audit sheets.	EMT

*Appropriate for large facilities and/or sophisticated teams only.

ESTIMATING SAVINGS

The worksheets in Section 4-1 will help the Energy Management Team prepare accurate estimates of the energy savings and cost avoidance potentials of some of the Action Sheets. Although the estimates are not essential to the Energy Management Program, they will help refine targets and budget time and resources.

The estimate sheets can be completed by a nontechnical person using a pocket calculator. No complex analyses are required. Naturally, a person with technical expertise would be able to help the team understand the calculations and the results.

Prepare estimate sheets for each component space in Series FB. If you use a space division based on characteristics of energy use, you will eliminate some problems of aggregating and apportioning energy use.

The worksheets combine data from the completed audits and surveys with information gathered for this use alone. The SOURCE column designations are:

1. The Facility Survey, indicated as FA plus the number of a survey section.

2. The Expanded Facility Survey, indicated as FB plus its section number.

3. Other sections of these worksheets, indicated worksheet section number and an item number within that section.

4. Basic Data and Reference Tables, at the end of Section II.

Where no source for the data is indicated, make an estimate of the required value for the space(s) under consideration.

Estimates that treat sections of the building in isolation cannot be precise. Positive or negative side-effects often result when seemingly independent modifications are combined. On some of the estimate sheets, several effects have been combined into one percentage equivalent; on others actions on one part of a sheet affect other calculations.

Estimating procedures are not provided for all the energy management actions, mostly because of the complexity of some calculations. In fact, some savings cannot be estimated without computer assistance, although fortunately, most savings result through actions for which simple procedures exist.

The calculations and procedures in this worksheet section are drawn from several sources. The overall concept and many of the calculations were developed for the U.S. Department of Energy, through contract with the State of Colorado, by the Energy Conservation Alternatives Center for Commerce and Industry (ECAC). Other procedures and modifications to the ECAC procedures have been made using data from the Guidelines for Saving Energy in Existing Buildings, ECM 1 and 2 and from the Public Schools Energy Conservation Service (PSECS), developed and managed by EFL.

Conversion to Cost Avoidance Dollars

To convert the Btu's of the following estimates to cost avoidance dollars divide the estimated annual Btu savings by the appropriate Btu's per dollar calculated in the following procedure:

DATA REQUIRED	SOURCE	VALUE
A. Type of fuel used		_____
B. Unit of fuel purchase		_____
C. Present cost per unit		$_____ per unit
D. Inflation factor, Worksheet 3-2.3 or use 1.00		_____
E. Energy content per unit	Table IA	_____ Btu/unit
F. Current cost per kwh		$_____ per kwh
G. Electric inflation factor, Worksheet 3-2.2 or use 1.00		_____

STEP 1: Calculate Btu per dollar for heating fuel.

$$\frac{\text{E}}{\text{_____}} \Big/ \left(\frac{\text{C}}{\text{_____}} \times \frac{\text{D}}{\text{_____}}\right) = \frac{\text{(1)}}{\text{_____}} \text{ Btu/\$}$$

STEP 2: Calculate Btu per dollar for noncooling use of electricity.

$$3{,}413 \Big/ \left(\frac{\text{F}}{\text{_____}} \times \frac{\text{G}}{\text{_____}}\right) = \frac{\text{(2)}}{\text{_____}} \text{ Btu/\$ (noncooling)}$$

STEP 3: Calculate Btu per dollar for cooling use of electricity.

$$12{,}000 \Big/ \left(\frac{\text{F}}{\text{_____}} \times \frac{\text{G}}{\text{_____}}\right) = \frac{\text{(3)}}{\text{_____}} \text{ Btu/\$}^{+}$$

+This number will be used on Worksheet 4-2.

THESE SAVINGS ESTIMATES COVER _____ or ( ) FACILITY

1. ENERGY CONSUMPTION FOR HEATING

Use this sheet to estimate the amount of heating energy required to maintain occupied conditions. Some of the variables calculated here will be used in later calculations.

DATA REQUIRED	SOURCE	VALUE
A. Total roof transmission factor (roof htf)	FB-2	_____ Btu/hr.°F
B. Total wall htf	FB-2	_____ Btu/hr.°F
C. Occupied space temperature	FB-5	___ °F
D. Average winter temperature	Table I	___ °F
E. Length of heating season	Table I	___ weeks
F. Minimum outside air *	FB-7	_____ cfm
G. Hours per week of fan use *	FB-5	___ hours

STEP 1: Calculate total enclosure htf.

$$\underset{A}{____} + \underset{B}{____} = \underset{(1)}{____} \text{ Btu/hr.°F}$$

STEP 2: Calculate seasonal heat loss of enclosure.

$$\underset{(1)}{____} \times (\underset{C}{____} - \underset{D}{____}) \times 24 \times 7 \times \underset{E}{____} = \underset{(2)}{____} \text{ Btu}$$

STEP 3: Calculate equivalent htf of outside air. *

$$\underset{F}{____} \times 1.08 = \underset{(3)}{____} \text{ Btu/hr.°F}$$

STEP 4: Calculate seasonal heating load of outside air. *

$$\underset{(3)}{____} \times (\underset{C}{____} - \underset{D}{____}) \times \underset{G}{____} \times \underset{E}{____} = ____ \text{ Btu}$$

STEP 5: Calculate total seasonal heating load.

$$\underset{(2)}{____} + \underset{\substack{(4)\\ \text{or zero}}}{____} = \underset{(5)}{____} \text{ Btu}$$

* Skip if facility or space has no fans in heating system.

*2. ENERGY CONSUMPTION FOR COOLING

Use this sheet to calculate the energy required for mechanical cooling. Some of the variables calculated here will be used later in further calculations.

DATA REQUIRED	SOURCE	VALUE
A. Floor area of space	FB-1	_____ square feet
B. Square feet per ton of cooling	Table III	_____ square feet
C. Approximate power input	Table IV	_____ kw/ton
D. Equivalent cooling hours	Table V	_____ hours/year

STEP 1: Calculate cooling capacity required.

$\frac{\text{_____}}{A} / \frac{\text{_____}}{B} = \frac{\text{_____}}{(1)}$ tons

STEP 2: Calculate cooling design loan (cdl).

For electric: $\frac{\text{_____}}{(1)}$ x 12,000 Btu hr./ton = $\frac{\text{_____}}{(2E)}$ Btu/hr.

For gas: $\frac{\text{_____}}{(1)}$ x 19,000 Btu hr./ton = $\frac{\text{_____}}{(2G)}$ Btu/hr.

STEP 3: Determine power requirement (electric only).

$\frac{\text{_____}}{(1)} \times \frac{\text{_____}}{C} = \frac{\text{_____}}{(3)}$ kw/hr. (zero if not electric)

STEP 4: Calculate annual cooling electric use.

$\frac{\text{_____}}{(3)} \times \frac{\text{_____}}{D} = \frac{\text{_____}}{(4)}$ kwh/year (zero if not electric)

STEP 5: Calculate seasonal cooling load (scl).

For electric: $\frac{\text{_____}}{(4)}$ x 3,413 = $\frac{\text{_____}}{(5E)}$ Btu/year +

For gas: $\frac{\text{_____}}{(2G)} \times \frac{\text{_____}}{D} = \frac{\text{_____}}{(5G)}$ Btu/year +

*Skip if plant is not mechanically cooled.
+This number will be used on worksheet 4-1.18.

3. ADJUST THERMOSTATS TO LOWER (HEATING) AND HIGHER (COOLING) SETTINGS.

USE WITH ACTION SHEETS A-4, A-9, S-1, C-1.

DATA REQUIRED	SOURCE	VALUE
A. Total htf	Worksheet 4-1.3 (add (1) and (3))	_____ Btu/hr.°F
B. Heating season weeks per year	Table I	_____ weeks
C. Heating hours per week	FB-5	_____ hrs./wk.
D. Heating season occupied temperature	FB-5	_____ °F
E. New occupied temperature		_____ °F
*F. Cooling season weeks per year	Table I	_____ weeks
*G. Cooling hours per week	FB-6	_____ hrs./wk.
*H. Cooling season occupied temperature	FB-6	_____ °F
*I. New occupied temperature		_____ °F

STEP 1: Calculate heating fuel savings.

$$\frac{\quad}{A} \times \left(\frac{\quad}{D} - \frac{\quad}{E}\right) \times \frac{\quad}{C} \times \frac{\quad}{B} = \frac{\quad}{(1)} \text{ Btu/year}$$

*STEP 2: Calculate cooling energy savings.

$$\frac{\quad}{A} \times \left(\frac{\quad}{I} - \frac{\quad}{H}\right) \times \frac{\quad}{F} \times \frac{\quad}{G} = \frac{\quad}{(2)} \text{ Btu/year}$$

STEP 3: Calculate total savings.

$$\frac{\quad}{(1)} + \frac{\quad}{(2)} = \frac{\quad}{(3)} \text{ Btu/year}$$

*Skip if plant is not mechanically cooled.

4. ELIMINATE HEATING AND COOLING OF VACANT SPACES DURING OCCUPIED PERIODS.

USE WITH ACTION SHEET A-6.

DATA REQUIRED	SOURCE	VALUE
A. Total htf	4-1.3, step 2	_____ Btu/hr./°F
B. Roof area	FB-2	_____ sq. ft.
C. Wall area	FB-3	_____ sq. ft.
D. Vacant space roof area		_____ sq. ft.
E. Vacant space wall area		_____ sq. ft.
F. Heating season weeks per year	Table I	_____ weeks
G. Heating hours per week	FB-5	_____ hrs./wk.
H. Heating season occupied temperature	FB-5	_____ °F
I. New vacant space temperature		_____ °F
*J. Floor area	FB-1	_____ sq. ft.
*K. Vacant space floor area		_____ sq. ft.
*L. Cooling season weeks per year	Table I	_____ weeks
*M. Cooling hours per week	FB-6	_____ hours/wk.
*N. Cooling season occupied temperature	FB-6	_____ °F
*O. New vacant space temperature		_____ °F

STEP 1: Calculate htf ratio.

$$\left(\frac{\quad}{D} + \frac{\quad}{E}\right) / \left(\frac{\quad}{B} + \frac{\quad}{C}\right) = \frac{\quad}{(1)}$$

STEP 2: Calculate heating energy savings.

$$\frac{\quad}{A} \times \left(\frac{\quad}{H} - \frac{\quad}{I}\right) \times \frac{\quad}{F} \times \frac{\quad}{G} \times \frac{\quad}{(1)} = \frac{\quad}{(2)} \text{ Btu/yr.}$$

*STEP 3: Calculate cooling load ratio.

$$\frac{\quad}{K} / \frac{\quad}{J} = \frac{\quad}{(3)}$$

*STEP 4: Calculate cooling energy savings.

$$\frac{\quad}{A} \times \left(\frac{\quad}{O} - \frac{\quad}{N}\right) \times \frac{\quad}{L} \times \frac{\quad}{M} \times \frac{\quad}{(3)} = \frac{\quad}{(4)} \text{ Btu/yr.}$$

*Skip if plant is not mechanically cooled.

5. SET BACK SPACE TEMPERATURE DURING UNOCCUPIED PERIODS.

USE WITH ACTION SHEETS A-1, A-2, A-8.

DATA REQUIRED	SOURCE	VALUE
A. Total htf	Worksheet 4-1.3, step 1	_____ Btu/hr./°F
B. Heating season weeks per year	Table I	_____ weeks
C. Heating hours per week	FB-5	_____ hrs./wk.
D. Old unoccupied space temperature (heating)		_____ °F
E. New unoccupied space temperature (heating)		_____ °F
*F. Cooling season weeks per year	Table I	_____ weeks
*G. Cooling hours per week	FB-6	_____ hrs./wk.
*H. Old unoccupied space temperature (cooling)		_____ °F
*I. New unoccupied space temperature (cooling)		_____ °F

STEP 1: Calculate weekly unoccupied hours during heating season.

$$168 - \underset{C}{____} = \underset{(1)}{____} \text{ hours/week}$$

STEP 2: Calculate heating energy savings.

$$\underset{A}{____} \times (\underset{D}{____} - \underset{E}{____}) \times \underset{B}{____} \times \underset{(1)}{____} = \underset{(2)}{____} \text{ Btu/year}$$

*STEP 3: Calculate weekly unoccupied hours during cooling season.

$$168 - \underset{G}{____} = \underset{(3)}{____} \text{ hours/week}$$

*STEP 4: Calculate cooling energy savings.

$$\underset{A}{____} \times (\underset{I}{____} - \underset{H}{____}) \times \underset{F}{____} \times \underset{(3)}{____} = \underset{(4)}{____} \text{ Btu/yr.}$$

*Skip if plant is not mechanically cooled.

6. REDUCE INCANDESCENT LIGHTING KWH USE.

USE WITH ACTION SHEET L-1.

Three methods of calculation are used: one costs nothing and two require capital investment. One of the capital methods maintains current lighting level but uses more efficient systems; the other raises (or lowers) the lighting level to one recommended by good practice.

a. Reduce wattage of incandescent lamps in use (no cost).

DATA REQUIRED	SOURCE	VALUE
A. Number of incandescent bulbs affected		_____ bulbs
B. Reduction in watts per bulb		_____ watts
C. Annual incandescent usage	FB-4	_____ hrs./year

STEP 1: Calculate annual Btu savings.

$\underset{A}{_____} \times \underset{B}{_____} \times \underset{C}{_____} \times 3.413 = \underset{(1)}{_____}$ Btu/year

b. Replace incandescent lighting with more efficient system but maintain approximately the same lighting level (medium-cost capital).

DATA REQUIRED	SOURCE	VALUE
D. Total incandescent wattage affected	FB-4	_____ watts
E. Lumen output ratio	Table VI	_____

STEP 2: Calculate replacement wattage for new system.

$\underset{D}{_____} / \underset{E}{_____} = \underset{(2)}{_____}$ watts

STEP 3: Calculate annual Btu savings.

$(\underset{D}{_____} - \underset{(2)}{_____}) \times \underset{C}{_____} \times 3.413 = \underset{(3)}{_____}$ Btu/year

c. Replace incandescent lighting with more efficient system, raise (or lower) level to that of good practice (medium or high-cost capital).

DATA REQUIRED	SOURCE	VALUE
F. Area lighted by incandescents		_____ sq. ft.
G. Recommended watts per square foot	Table VII	_____ watts/sq.ft.

STEP 4: Calculate replacement wattage of new system.

$$\underset{F}{_____} \times \underset{G}{_____} = \underset{(4)}{_____} \text{ watts}$$

STEP 5: Calculate annual Btu savings.

$$\left(\underset{D}{_____} - \underset{(4)}{_____}\right) \times \underset{C}{_____} \times 3.413 = \underset{(5)}{_____} \text{Btu/year}$$

7. REDUCE FLUORESCENT LAMP KWH USAGE.

USE WITH ACTION SHEETS L-2, L-5

Two methods, one no-cost, one low or medium-cost capital, are provided here.

a. Remove pairs of fluorescent tubes from fixtures.

DATA REQUIRED	SOURCE	VALUE
A. Number of tubes to be removed		_____ tubes
B. Wattage of each tube		_____ watts/tube
C. Ballasts: enter 1.0 if not disconnected, 1.2 if disconnected		_____
D. Annual fluorescent usage	FB-4	_____ hours/year

STEP 1: Calculate annual Btu savings.

$$\frac{\text{_____}}{A} \times \frac{\text{_____}}{B} \times \frac{\text{_____}}{C} \times \frac{\text{_____}}{D} \times 3.413 = \frac{\text{_____}}{(1)} \text{ Btu/year}$$

b. Replace fluorescent tubes with lower-wattage, higher-efficiency tubes, e.g. "watt-misers."

DATA REQUIRED	SOURCE	VALUE
E. Installed fluorescent lighting	FB-4	_____ kw

STEP 2: Calculate annual Btu savings.

$$\frac{\text{_____}}{E} \times \frac{\text{_____}}{D} \times 1000 \times 0.15 \times 3.413 = \frac{\text{_____}}{(2)} \text{ Btu/year}$$

8. REDUCE KWH USE FOR EXTERIOR LIGHTING.

USE WITH ACTION SHEET L-7.

This sheet describes three methods, two of which require capital investment. Exercise extreme caution before altering the amount or use of outdoor lighting for security and/or safety.

a. Use lamps of lower wattage rating in exterior lighting.

DATA REQUIRED	SOURCE	VALUE
A. Installed exterior wattage	FB-Summary	_____ watts
B. Annual use hours	FB-Summary	_____ hours/year
C. Number of lamps affected		_____ lamps
D. Wattage of each new lamp		_____ watts/lamp

STEP 1: Calculate replacement wattage.

$$\underset{C}{____} \times \underset{D}{____} = \underset{(1)}{____} \text{ watts}$$

STEP 2: Annual Btu savings.

$$(\underset{A}{____} - \underset{(1)}{____}) \times \underset{B \text{ or } E}{____} \times 3.413 = \underset{(2)}{____} \text{ Btu/year}$$

b. Install photocell controls on exterior lighting (low-cost capital).

DATA REQUIRED	SOURCE	VALUE
E. Photocell lighting use hours	Table VIII	_____ hrs./year

STEP 3: Annual Btu savings.

$$\underset{A \text{ or } (1)}{____} \times (\underset{B}{____} - \underset{E}{____}) \times 3.413 = \underset{(3)}{____} \text{ Btu/year}$$

c. Replace incandescent with more efficient types (no or low to medium-cost).

DATA REQUIRED	SOURCE	VALUE
F. Lumen output ratio	Table VI	_____

STEP 4: Annual Btu savings.

$$[\underset{A}{____} - (\underset{A}{____} / \underset{F}{____})] \times \underset{B \text{ or } E}{____} \times 3.413 = \underset{(4)}{____} \text{ Btu/year}$$

9. REDUCE UNNECESSARY USE OF LIGHTING.

USE WITH ACTION SHEET L-3.

a. Turn off lights in spaces vacant during occupied building hours.

This calculation assumes that a five percent total savings will be achieved from using this approach. Results may vary depending on discipline of space users.

DATA REQUIRED	SOURCE	VALUE
A. Installed lighting kw	FB-4	_____ kw
B. Annual lighting usage	FB-4	_____ hours/year

STEP 1: Calculate annual Btu savings.

$$\underset{A}{_____} \times \underset{B}{_____} \times 0.05 \times 3{,}413 = \underset{(1)}{_____} \text{ Btu/year}$$

b. Rewire switching circuits to permit greater local control of lights.

This calculation requires that you redesign and recalculate each lighting circuit. Create new circuits to alleviate problems with current switching, such as large room with no switching subdivision, etc.

DATA REQUIRED	SOURCE	VALUE
C. Number of lamps on circuit		_____ lamps
D. Watts per lamp		_____ watts/lamp
E. Current annual usage	FB-4	_____ hours/year
F. Annual use after rewiring		_____ hours/year

STEP 2: Calcuate annual Btu savings.

$$\underset{C}{_____} \times \underset{D}{_____} \times (\underset{E}{_____} - \underset{F}{_____}) \times 3.413 = \underset{(2)}{_____} \text{ Btu/year}$$

10. INCREASE ROOF INSULATION.

USE WITH ACTION SHEET B-2.

DATA REQUIRED	SOURCE	VALUE
A. Roof area	FB-2	_____ Sq. Ft.
B. Roof U value	FB-2	_____ Btu/hr.°F/ft.^{2}
C. New roof U value		0.05 Btu/hr.°F/ft.^{2}
D. Normal heating degree-days	FB-Summary	_____
*E. Normal cooling degree-days	FB-Summary	_____

STEP 1: Calculate annual Btu savings during heating season.

$$\underset{A}{____} \times (\underset{B}{____} - \underset{C}{____}) \times \underset{D}{____} \times 24 = \underset{(1)}{____} \text{ Btu/year}$$

*STEP 2: Calculate annual Btu savings during cooling season.

$$\underset{A}{____} \times (\underset{B}{____} - \underset{C}{____}) \times \underset{E}{____} \times 24 = \underset{(2)}{____} \text{ Btu/year}$$

STEP 3: Total annual Btu savings.

$$\underset{(1)}{____} + \underset{(2) \text{ or zero}}{____} = \underset{(3)}{____} \text{ Btu/year}$$

*Skip if plant is not mechanically cooled.

11. REDUCE HEAT TRANSMISSION THROUGH GLASS AREAS.

USE WITH ACTION SHEETS B-3 and B-4.

a. Install double or triple-pane windows (high-cost modification).

DATA REQUIRED	SOURCE	VALUE
A. Window area to be replaced		_____ sq. ft.
B. Select appropriate U value for existing glass: Single-pane = 1.13 Double-pane = 0.58 Triple-pane = 0.36		_____ Btu/hr.°F/ft.^{2}
C. Select appropriate U value for replacement glass.		_____ Btu/hr.°F/ft.^{2}
D. Normal annual heating degree-days	FB-Summary	_____
*E. Normal annual cooling degree-days	FB-Summary	_____

STEP 1: Calculate annual Btu savings during heating season.

$$\underset{A}{____} \times (\underset{B}{____} - \underset{C}{____}) \times \underset{D}{____} \times 24 = \underset{(1)}{____} \text{ Btu/year}$$

*STEP 2: Calculate annual Btu savings during cooling operations.

$$\underset{A}{____} \times (\underset{B}{____} - \underset{C}{____}) \times \underset{E}{____} \times 24 = \underset{(2)}{____} \text{ Btu/year}$$

STEP 3: Total annual Btu savings.

$$\underset{(1)}{____} + \underset{(2) \text{ or zero}}{____} = \underset{(3)}{____} \text{ Btu/year}$$

b. Replace glass areas with insulating panels (high-cost modification)

Assume replacement equal to recommended wall R value for area.

DATA REQUIRED	SOURCE	VALUE
F. Recommended wall U value		0.10 Btu/hr.°F/ft.^{2}

STEP 4: Calculate annual Btu savings during heating season.

$$\underset{A}{____} \times (\underset{B}{____} - \underset{F}{____}) \times \underset{D}{____} \times 24 = \underset{(4)}{____} \text{ Btu/year}$$

*Skip if plant is not mechanically cooled.

*STEP 5: Calculate annual Btu savings from cooling operations.

$$\frac{\quad}{A} \times \left(\frac{\quad}{B} - \frac{\quad}{F}\right) \times \frac{\quad}{E} \times 24 = \frac{\quad}{(5)} \text{ Btu/year}$$

Note that this method neglects the effect of reduced solar heat gain by multiple-pane glass. This effect is slight for these elements.

STEP 6: Total annual Btu savings.

$$\frac{\quad}{(4)} + \frac{\quad}{(5 \text{ or zero})} = \quad \text{Btu/year}$$

*Skip if plant is not mechanically cooled.

12. REDUCE VENTILATION RATE DURING OCCUPIED PERIODS.

USE WITH ACTION SHEET V-1.

DATA REQUIRED	SOURCE	VALUE
A. Total air system cfm capacity	FB-7	_____ cfm
B. Minimum outside air percentage	FB-7	_____ pct.
C. Average occupancy (fully used)		_____ people
D. Select minimum ventilation rate: 5 cfm if no smoking 8 cfm if mixed smoking/no smoking 15 cfm if smoking		_____ cfm
or use governing code requirements		
E. Average winter outdoor temperature	Table I	_____ °F
F. Occupied heating temperature	FB-5	_____ °F
G. Heating season hours per week	FB-5	_____ hours/week
H. Weeks in heating season	Table I	_____ weeks
*I. Average summer outdoor temperature	Table I	_____ °F
*J. Occupied cooling temperature	FB-6	_____ °F
*K. Cooling season hours per week	FB-6	_____ hours
*L. Cooling season weeks	Table I	_____ weeks

STEP 1: Calculate excess outside air intake

$$(\underset{A}{____} \times \underset{B}{____}/100) - \underset{C}{____} \times \underset{D}{____} = \underset{(1)}{____} \text{ cfm}$$

STEP 2: Calculate annual Btu savings during heating season.

$$\underset{(1)}{____} \times (\underset{F}{____} - \underset{E}{____}) \times \underset{G}{____} \times \underset{H}{____} \times 1.08 = \underset{(2)}{____} \text{ Btu/yr.}$$

*STEP 3: Calculate annual Btu savings from cooling operations.

$$\underset{(1)}{____} \times (\underset{I}{____} - \underset{J}{____}) \times \underset{K}{____} \times \underset{L}{____} \times 1.08 = \underset{(3)}{____} \text{ Btu/yr.}$$

STEP 4: Total annual Btu savings.

$$\underset{(2)}{____} + \underset{(3) \text{ or zero}}{____} = \underset{(4)}{____} \text{ Btu/year}$$

*Skip if plant is not mechanicaly cooled.

13. CLOSE OUTSIDE AIR DAMPERS DURING UNOCCUPIED PERIODS.

USE WITH ACTION SHEET V-2.

This calculation assumes little or no damper leakage.

DATA REQUIRED	SOURCE	VALUE
A. Average winter temperature	Table I	_____ °F
B. Unoccupied heating temperature	FB-5	_____ °F
C. Heating hours per week	FB-5	_____ hours/week
D. Heating weeks per year	Table I	_____ weeks
E. Total air system cfm capacity	FB-7	_____ cfm
F. Minimum outside air percentage	FB-7	_____ pct.

STEP 1: Calculate outside air cfm.

$$\underset{E}{____} \times \underset{F}{____} / 100 = \underset{(1)}{____} \text{ cfm}$$

STEP 2: Calculate annual Btu savings.

$$\underset{(1)}{____} \times (\underset{B}{____} - \underset{A}{____}) \times 1.08 \times \underset{D}{____} \times$$

$$(168 - \underset{D}{____}) = \underset{(2)}{____} \text{ Btu/year}$$

Additional savings will result if the fans are shut down during unoccupied periods.

14. INSTALL AN AUTOMATIC TEMPERATURE CONTROL (Low- or medium-cost).

USE WITH ACTION SHEETS S-1, C-1.

Automatic temperature controls are assumed to reduce annual loads by about 12 percent.

DATA REQUIRED	SOURCE	VALUE
A. Seasonal heating load	Worksheet 4-1.3	_____ Btu/year
*B. Seasonal cooling load	Worksheet 4-1.4	_____ Btu/year

STEP 1: Calculate annual Btu savings during heating season.

$\frac{\text{_____}}{A} \times 0.12 = \frac{\text{_____}}{(1)}$ Btu/year

*STEP 2: Calculate annual Btu savings during cooling operations.

$\frac{\text{_____}}{B} \times 0.12 = \frac{\text{_____}}{(2)}$ Btu/year

STEP 3: Total annual Btu savings.

$\frac{\text{_____}}{(1)} + \frac{\text{_____}}{(2) \text{ or zero}} = \frac{\text{_____}}{(3)}$ Btu/year

*Skip if plant is not mechanically cooled.

15. REPLACE PILOT LIGHTS WITH INTERMITTENT IGNITION DEVICES.

USE WITH ACTION SHEET H-4.

Use this worksheet to calculate the effect of shutting off the pilot lights when the heating unit is not in use. Remember also to shut off the fuel supply to the entire heating unit. The pilot lights used in heating units use about one therm of gas per year.

DATA REQUIRED	SOURCE	VALUE
A. Heating weeks per year	Table I	_____ weeks
B. Number of heating pilot lights		_____ pilots

STEP 1: Calculate annual Btu savings.

$$\underset{B}{_____} \times (52 - \underset{A}{_____}) / 52 \times 108{,}000 = \underset{(1)}{_____} \text{ Btu/year}$$

16. IMPROVE EFFICIENCY OF BOILER PLANT.

USE WITH ACTION SHEET H-3, H-5, H-7, H-8

Use this worksheet to calculate the savings from various efficiency improvements to the boilers. The first is simply improved maintenance, the second a capital improvement to existing equipment and the third is replacement of existing boilers.

a. Improve maintenance of existing boiler plant (no-cost).

DATA REQUIRED	SOURCE	VALUE
A. Seasonal heating load*	4-1.3 step 4	_____ Btu/year
B. Assume 10 percent improvement in efficiency from better maintenance.		

STEP 1: Calculate annual Btu savings.

$\frac{\text{_____}}{A} \times 0.10 = \frac{\text{_____}}{(1)}$ Btu/year

b. Add baffles ("turbulators") to existing boilers (low to middle-cost).

DATA REQUIRED	SOURCE	VALUE
C. Efficiency improvement: use 0.10 for old boilers 0.03 for new boilers		_____

STEP 2: Calculate annual Btu savings.

$\frac{\text{_____}}{A} \times \frac{\text{_____}}{C} = \frac{\text{_____}}{(2)}$ Btu/year

c. Replace existing boilers with more efficient units (medium to high-cost).

DATA REQUIRED	SOURCE	VALUE
D. Efficiency of existing unit(s)	FA-9	_____ pct.
E. Efficiency of new units	Table IX	_____ pct.

STEP 3: Calculate annual Btu savings.

$\left(1 \,/\, \frac{\text{_____}}{D} - 1 \,/\, \frac{\text{_____}}{E}\right) \times 100 \times \frac{\text{_____}}{A} = \frac{\text{_____}}{(3)}$ Btu/year

*Only that portion of seasonal load provided by the boiler set being studied. Seasonal load may be roughly apportioned by heating capacity of set under study to total plant heating capacity using FA-9 data.

17. REDUCE ENERGY USED IN HEATING DOMESTIC HOT WATER

USE WITH ACTION SHEETS W-1, W-2, W-3.

a. Lower temperature of domestic hot water.

DATA REQUIRED	SOURCE	VALUE
A. Average daily occupancy		_____ people
B. Daily per capita hot water use	Table X	_____ gal./person
C. Days per year used		_____ days/year
D. Present hot water temperature		_____ °F
E. Reset hot water temperature		_____ °F
F. Assume 8.33 Btu gal./°F for heating		

STEP 1: Calculate annual consumption.

$\underset{A}{____} \times \underset{B}{____} \times \underset{C}{____} = \underset{(1)}{____}$ gallons per year

STEP 2: Calculate annual Btu savings.

$\underset{(1)}{____} \times (\underset{D}{____} - \underset{E}{____}) \times 8.33 = \underset{(2)}{____}$ Btu/year

18. REDUCE ENERGY USED IN HEATING INDOOR SWIMMING POOL

USE WITH ACTION SHEET P-1.

Lower temperature of pool water.

DATA REQUIRED	SOURCE	VALUE
A. Surface area of pool		_____ square feet
B. Present pool water temperature		_____ °F
C. New pool water temperature		_____ °F
D. Length of pool heating season per year		_____ days

STEP 1: Calculate annual Btu savings.

$$\underset{A}{_____} \times (\underset{B}{_____} - \underset{C}{_____}) \times \underset{D}{_____} \times 65.5 = _____ \text{ Btu/year}$$

(Source: Public Schools Energy Conservation Service)

COST-BENEFIT ANALYSIS

MODIFICATION _____

DATA REQUIRED	SOURCE	VALUE
A. First cost of modification	Consultant	$_____
B. Annual energy savings	Consultant	_____ Btu/year
C. Heating energy cost	Worksheet 4-1.2	_____ Btu/dollar
D. Effect of modification on other annual operating costs	Consultant	$_____
E. Estimated lifetime of modification	Consultant	_____ years
F. Present worth factor for lifetime at discount rate	Consultant	_____

STEP 1: Preliminary calculations

(1) Annual operating cost change

$$\left(\frac{\text{_____}}{B} \Big/ \frac{\text{_____}}{C}\right) + \frac{\text{_____}}{D} = \frac{\text{_____}}{(1)} \text{ dollars/year}$$

(2) Present value of annual savings over lifetime of modification

$$\left(\frac{\text{_____}}{(1)} \times \frac{\text{_____}}{F}\right) = \frac{\text{_____}}{(2)} \text{ dollars}$$

STEP 2: Calculate simple payback.

$$\frac{\text{_____}}{A} \Big/ \frac{\text{_____}}{(1)} = \text{_____} \text{ years}$$

STEP 3: Calculate return on investment

$$\left(\frac{\text{_____}}{(1)} \Big/ \frac{\text{_____}}{A}\right) \times 100 = \text{_____}\%$$

STEP 4: Calculate benefit/cost ratio

$$\frac{\text{_____}}{(2)} \Big/ \frac{\text{_____}}{A} = \text{_____}$$

A retrofit is profitable if the benefit/cost ratio is greater than 1.0.

STEP FIVE: ESTABLISH GOAL

This worksheet outlines the activities of Step Five of the Energy Management Program. As each activity is completed, it should be checked off this list. The referenced worksheets follow this sheet.

	Activity	Responsible
( )	Prepare Energy Management Program goals statement (Use Worksheet 5-1).	EMT
( )	If capital modifications are appropriate, prepare "Maxi-Audit" development sheet. See Section II, "Maxi-Audit" article.	EMT, Volunteer
( )	Obtain Volunteer Board approval of goals statement and "Maxi-Audit" development.	Board

Non-Program Activity

( )	Publicize adoption of energy management goals by Volunteer Board.	

GOALS STATEMENT

If you completed the advanced Facility Audit (FB) and savings estimates (Worksheet 4 series), complete the following statement and submit it to the Volunteer Board of the agency for adoption as policy.

Upon the recommendation of the Energy Management Team of

(facility)_____,

The Volunteer Board of (agency)_____

amends its energy policy statement of (date)_____ to include the following specific energy use reduction goals for (year)_____:

(1) For electricity, a reduction of _____ percent representing an estimated cost avoidance of $_____ for the year;

(2) For _____(fuel), a reduction of _____percent representing an estimated cost avoidance of $_____ for the year.

These savings goals are based on a detailed examination of the energy situation at the facility, the identification of numerous energy saving actions and a commitment by the Board and facility staff to implementing a recommended Action Plan to save energy.

STEP SIX: DEVELOP ACTION PLAN

This worksheet outlines the activities of Step Six of the Energy Management Program. As each activity is completed, it should be checked off the list.

	Activity	Responsible
( )	Indicate responsibility and completion date for each Action Self-Audit activity to be undertaken.	EMT
( )	Transfer activities from Action Self-Audit sheets to individual responsibility lists (use Worksheet 6-1).	EMT
( )	Develop detailed Space Use Action Plan.	Program Director
( )	Develop detailed O&M Action Plan.	Operating Manager
( )	Review detailed Action Plans.	EMT

Retrofit Activities

( )	Review "Maxi-Audit" and retrofit recommendations.	EMT, design professional
( )	Prepare recommendations for retrofits for Board.	EMT
( )	Secure Volunteer Board approval for retrofits and obtain funding.	EMT, Board

INDIVIDUAL ACTION LISTS

On the Action Sheets, energy saving activities are grouped by problem or problem area. While this is effective for performing the Action Self-Audit and for keeping over-all program records, it does not lend itself to use as a work plan.

This worksheet develops individual Action Plan outlines by relisting actions on individual activity lists. To complete his or her individual task list, each team member should go through the Action Sheets and list on the following sheet (make extra copies first) the Action Sheet number, action description and completion date of all DO THESE section actions assigned to them.

The resulting lists will outline the over-all Action Plan responsibilities of each team member. These will serve both as checklists of activities and as a basis for developing more detailed, specific Action Plans. Each participant should assume responsibility for completing his or her Plan area, including the work of all subordinates.

STEP SIX - DEVELOP ACTION PLAN — INDIVIDUAL ACTION LIST

ACTION PLAN TASKS OF _____ (name) Page ___ of ___

Action Sheet	Action Task	Completion Date

STEP SEVEN: IMPLEMENT PLAN

This worksheet outlines the activities of Step Seven of the Energy Management Program. As each step is completed, it should be checked off the list.

	Activity	Responsible
( )	Implement space use Action Plan.	Program Director
( )	Implement C&M Action Plan (see Worksheet 7-1).	Operating Manager
( )	Indicate completion of implementation of each activity on Action Self-Audit Sheets.	Program Director, Operating Manager
( )	Review progress of implementation.	EMT
	Retrofit Activities	
( )	Implement retrofits.	Design professional

MAINTAINING A BOILER LOG

The following pages are master sheets for developing and maintaining a log for each set of boilers in your facility. Maintaining a boiler log helps achieve several energy management objectives, including improved maintenance, greater knowledge of energy use and increased awareness of task responsibilities. One large public agency managing several hundred buildings maintains boiler logs simply to insure that the boiler room is visited regularly.

The master boiler log sheets contain space for listing and describing boiler room equipment and for keeping records of periodic maintenance, efficiency checking and daily operations. While small facilities may do it less often, large facilities should keep a daily log.

To begin the log, make enough copies of each master sheet to cover all facility boiler sets (there are often two or more boilers in each set) and to provide several weeks of recording space in the daily section. Sheets should be bound into loose-leaf notebooks, one for each set, and the notebooks kept near the relevant boiler sets. Then,

1. Enter a description of the equipment associated with the boiler set.

2. Enter the most recent flue gas analysis (combustion efficiency test).

3. Enter the most recent major maintenance of the boiler set.

4. Enter the required daily data:

    a. The date and time of recording. Use a set time for each day that reflects steady load conditions, such as noon or mid or late morning.

    b. Outdoor temperatures. Use a thermometer that records maximum and minimum temperatures as well as showing current temperatures.

    c. Fuel used since the last report. Record either the actual use, the meter reading or the fuel level remaining. If the boiler uses oil, this may require daily dipsticking of the tank. If coal, daily fuel use may not be available.

    d. Supply and return water temperatures or steam pressure and temperature. Note the time of recording.

    e. Boilers that are on-line and hot. Place an X in the relevant column(s).

    f. Any problems, maintenance deficiencies or other information. Dated and initialed notes. Review this section weekly to insure that needed actions have been performed.

LOG FOR BOILER SET # _____

LOCATED IN _____ (room) OF _____ (building)

LOG IS KEPT AT _____ (location)

This log is to be kept at the above location and maintained daily by personnel operating this boiler set.

Equipment Description

BOILER # 1 Input rating _____ mbh* Output rating _____ mbh*

Manufacturer/model _____

BOILER # 2 Input rating _____ mbh* Output rating _____ mbh*

Manufacturer/model _____

BOILER # 3 Input rating _____ mbh* Output rating _____ mbh*

Manufacturer/model _____

TYPE ( ) Firetube ( ) Electric resistance
( ) Watertube ( ) Electrode
( ) Other _____

FUEL _____ STANDBY _____

( ) Boiler set produces STEAM.

Steam pressure: high fire _____ psig; low fire _____ psig

Condensate pumps: number _____ Total hp _____

( ) Boiler set produces HOT WATER.

Hot water supply temperature _____ °F

Circulating pumps: number _____ Total hp _____

( ) Boiler set also produces domestic hot water.

Storage tank capacity _____ gallons; temperature _____ °F

*1 boiler horsepower (hp) = 33.5 mbh

FLUE GAS ANALYSIS LOG BOILER SET # ____

Date	Tested by	Boiler	Boiler efficiency	Percent CO	Stack temperature	Notes
		#1				
		#2				
		#3				
		#1				
		#2				
		#3				
		#1				
		#2				
		#3				
		#1				
		#2				
		#3				
		#1				
		#2				
		#3				

MAINTENANCE LOG

Date	Maintenance Activities	Performed by

DAILY OPERATIONS LOG STEAM BOILER SET # ____

Date/Time	Outdoor temperature			24-hour fuel use	Steam		Boilers on-line			Initials
	Current	24-hour Maximum	24-hour Minumum		Temp. °F	Press. psig	1	2	3	

Notes

DAILY OPERATIONS LOG HOT WATER BOILER SET # ____

Date/Time	Outdoor temperature 24-hour			24-hour fuel use	Water temperature		Boilers on-line			Initials
	Current	Maximum	Minumum		Supply	Return	1	2	3	

Notes

STEP EIGHT: MONITOR CONSUMPTION

This worksheet outlines the activities of Step Eight of the Energy Management Program. As each activity is completed, it should be checked off the list.

	Activity	Responsible
( )	Read meters and measure other fuel use on the first of each month. Record this information on copies of Worksheets E from Step Three.	Operating Mgr., EMC
( )	Enter monthly usages on large wall charts to show facility users the results of the program.	EMC

STEP NINE: EVALUATE PROGRAM

The following is suggested as an outline for your team's evaluation of the energy management program.

1. Was the goal accomplished?
2. What system (human, energized, nonenergized) contributed what proportion of the goal?
3. What is the next goal, and what are the next actions?
4. If the goal was not met, what were the reasons?
5. What impact did energy management have on clients, staff, agency programs and team members? Who else was affected, and in what way?
6. What were the principal lessons learned?
7. Were there any surprises?
8. Were the right people on the team?
9. Should the team continue; should there be changes in personnel?
10. Should there be any changes in the administration and operation of the agency to improve energy management?

THE NATIONAL ASSEMBLY MEMBER AGENCIES

AFL-CIO, Department of Community Services
American Council for Nationalities Service
American Foundation for the Blind
American Red Cross
Association of Junior Leagues
Big Brothers/Big Sisters of America
Boys Clubs of America
Boy Scouts of America
Camp Fire
Child Welfare League of America
Council of Jewish Federations
Family Service Association of America
Girl Scouts of the U.S.A.
Girls Clubs of America
Goodwill Industries of America
International Social Service/American Branch
JWB
Lutheran Council in the U.S.A., Division of Mission and Ministry
National Conference of Catholic Charities
National HomeCaring Council
National Council of Jewish Women
National Council of Negro Women
The National Council on the Aging
National Mental Health Association
The National Network of Runaway and Youth Services
National Youth Work Alliance
A. Philip Randolph Educational Fund
The Salvation Army
Travelers Aid Association of America
United Neighborhood Centers of America
United Seamen's Service
USO
United Way of America
The Volunteers of America
YMCAs, National Board of
YWCA of the U.S.A., National Board